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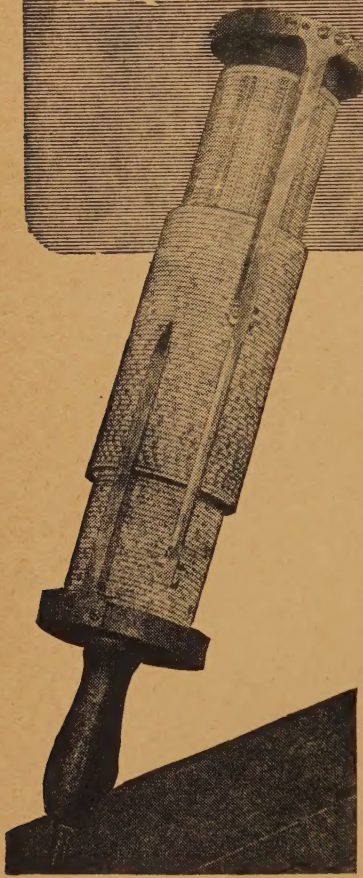

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THE PROPERTIES AND USES OF CONIFER THINNINGS IN GREAT BRITAIN

By C. W. SCOTT[1]

(*Department of Scientific and Industrial Research, Forest Products Research Laboratory*)

SUMMARY.

The paper, read at the British Association meeting at Edinburgh in August 1951, considers shortly the evidence on the suitability of home-grown conifer thinnings as pit-props. Two examples of other good uses for conifer thinnings are cited, one in the Forestry Commission's new forest in East Anglia and one by private enterprise near Chester. Figures are given to show the very considerable quantities of conifer thinnings available in 1951 and likely to be available in 1961. The effect of rapid growth and pruning on conifer wood quality and use is discussed and the writer's opinion recorded that as high quality timber as possible should be aimed at. Too much reliance should not be placed on increases in chemical and pulping developments where knots may be unimportant. In sawn timber knots are often a critical factor.

INTRODUCTORY.

THE straightness and regularity of conifer thinnings are an asset in practical uses of prime national importance such as pit-props in coal-mines. The early money income provided by thinnings, when saleable, is also a most important help to the grower, especially in Great Britain where planting costs are high and a very heavy planting programme is necessary to repair years of neglect of sound forestry and common sense.

The poor market for home-grown conifer thinnings in the past, at least in the forest areas at some distance from the coalfields, has been a serious discouragement to private enterprise. It is fortunate that in spite of this the private owners had grown enough to bridge the gap between the country's needs and its imports during the First World War and critical submarine campaign; and during the Second War and sea campaign the private owners again, with the help of the young State forests, met the vital needs of the mines and other industries dependent on wood, so far as imports were not to be had.

Today the picture is brighter in some respects. It is brighter both for the country in the matter of the fast-swelling volume of available thinnings, and for the grower, whether private owner or Forestry Commission, because new markets are developing, such as paper-pulp and fibre-board, to supplement and fit in with the older and still vital market of mining timber. Also the ingenuity and enterprise of some private operators have found ways of making box-boards and other

[1] Mr. C. W. Scott was Editor of this *Journal* from 1946 to the end of 1950 and so was responsible for the production of Volumes XX to XXIII inclusive. In addition the greater part of the material for Volume XXIV was selected by him. It is with considerable pleasure, therefore, that we are able to welcome him as a contributor in the first number of Volume XXV and at the same time record in these pages the Society's appreciation of his signal service as Editor during the past five years.

packaging material out of thinnings of a young age and small diameter. This is all to the good, especially in times of shortage of imported timber.

THE PROPERTIES OF HOME-GROWN CONIFER THINNINGS, WITH SPECIAL REFERENCE TO PIT-PROPS.

The proportions of home-grown and imported timber pit-props used in the British coal-mines have varied widely in peace and war, with price, availability, and other factors. Inevitably there have been comparisons, often influenced by the war-time emergency conditions under which the home-grown props have been produced. Sometimes the miner's opinion of poorly prepared lots of the home-grown prop has been poor, and rightly so, but on the whole that prop has stood the test of large-scale use very well. There is good scientific as well as practical evidence that properly selected and prepared home-grown props of any of the seven main conifer species discussed below compare favourably with imported props, from the Baltic or Bordeaux.

The strength and smoothness of a prop are important. They depend, obviously, on the inherent properties of the species concerned, i.e. common or Norway spruce (*Picea abies* Karst.), European larch (*Larix decidua* Mill.), Douglas fir (*Pseudotsuga taxifolia* Brit.), Japanese larch (*Larix leptolepis* Gord.), Scots pine (*Pinus sylvestris* L.), Corsican pine (*Pinus nigra* var. *calabrica* Schneid.), and Sitka spruce (*Picea sitchensis* Carr.), and also greatly on the growing conditions or silviculture of the particular forest or plantation concerned, and on the proper selection and preparation of the prop itself, from the tree. An intensive, thorough examination of the strength of some 2,000 home-grown pit-props, including all seven of the most important conifer species, from twenty-five localities of England, Scotland, and Wales, was made at the Forest Products Research Laboratory, Princes Risborough, Bucks. (Dept. of Scientific and Industrial Research), in 1941–7, by the laboratory in collaboration with the Forestry Commission who supplied the props. The results have been analysed in detail by Mr. F. H. Armstrong of the Timber Mechanics Section of the laboratory, and published by permission in *Forestry*, vol. xxi, No. 1, 1947, under the title 'The Strength of Home-Grown Timber Pit-Props'. (1)

From each locality there were tested at least twenty normal props of each of the four sizes most used in the mines, namely $2\frac{1}{2}$ in., $3\frac{1}{2}$ in., $4\frac{1}{2}$ in. and $5\frac{1}{2}$ in. top diameter. The maximum load under compression parallel with the grain was measured, for green home-grown props, and found to average, in rounded figures, from 2,100 lb. per sq. in. of mean diameter for Sitka spruce to 2,400 lb. for common or Norway spruce, compared with the average figures of other investigators, comparable though based on a smaller number of tests, of 2,300 lb. to 2,400 lb. for imported Scots pine from the Baltic, and 2,100 lb. for imported maritime pine (*Pinus pinaster* Ait.) from Bordeaux or south-west Europe. (This last is a major source of supply to the South Wales coalfield.) Sitka spruce was the least strong and Norway spruce the strongest of the home-grown props, with home-grown Scots pine in between at 2,200 lb.

The differences in strength between normal props of the seven home-grown species, amongst themselves, and between any of them and the imported props, were found to be small and of much less practical importance than the differences of strength within one species if excessive bow, as it is called, were included, i.e. deviation from the vertical. For in five of the seven species examined (all but the two spruces, Norway and Sitka) the Forestry Commission sent for test separate lots of what are called pre-thinnings, that is cleanings of 'wolf trees' and rough wood, with more bow, larger branches and knots, and faster growth (with correspondingly lighter wood) than in normal thinnings. Fortunately it is estimated that such pre-thinnings do not exceed 1 per cent. of the total, so that their exclusion from supplies to the mines, which is obviously desirable, involves no serious loss to the grower or lessening of pit-prop outturn.

The main results of the tests of all the 2,000 normal thinnings received, without selection or rejection at the laboratory but excluding the pre-thinnings, are tabled below:

Home-grown species	*Average strength difference as a percentage of the strength of*	
	Imported Scots pine from the Baltic	*Imported maritime pine from S.W. Europe (Bordeaux, &c.)*
Common or Norway spruce	0	+
European larch	0	+ (+The home-
Douglas fir	−2	+ grown are
Japanese larch	−7	+ stronger.)
Scots pine	−7	+
Corsican pine	−10	0
Sitka spruce	−13	−2

Reference is invited to Mr. Armstrong's paper for further details. Only two points can be touched on here. The test data and curves show that when bow exceeds ¼ inch horizontally per 1 foot vertical run of the prop, the strength begins to fall markedly. Some such limit of bow is desirable, therefore, so far as practice and urgencies of supply permit. The experienced suppliers and users of home-grown props have inevitable differences of opinion on price, but in practice they agree well on a reasonable standard of quality in props. Rejections are uncommon. The scientific tests at Princes Risborough have confirmed the good standard of straightness at which to aim. For good photographs of straight and crooked (and rough) timber in coal-face roof supports reference is invited to page 71 of Mr. H. Henshaw's very useful and practical work, *The Use of Timber in Mining*, published by the Timber Development Association, 21 College Hill, London, E.C. 4, as a free red booklet. (4)

The other point which emerges in Mr. Armstrong's analysis of the tests at Princes Risborough is that when the annual rings per inch fall below 8 for home-grown Scots pine or 6 for the other six species examined, the density and strength of the wood begin to decrease appreciably, because lighter and weaker wood is

usually associated with very fast growth, in young conifers in Great Britain. It would be wrong to draw sweeping conclusions from these data or try to reject all props with fewer annual rings per inch than 8 for Scots pine or 6 for the other species, unless practical experience shows that this is necessary. For the average annual rings per inch of the 2,000 normal thinnings tested at Princes Risborough, vide Mr. Armstrong's Table I, were 13½ for Scots pine and above 6 for all the other six species. It is advisable, however, to watch this feature, especially in Sitka spruce, the least strong and one of the fastest growing of the home-grown props; and to take whatever action is necessary if practical experience demands it. Straightness, cleanness, and uniformity of strength may outweigh other factors in practice. The essential is that the home-grown props should give satisfactory service in the mines. Timber unlikely to do so should go to other uses.

To sum up. Practical experience in two wars and in peace has shown that pit-props grown in Great Britain are satisfactory if properly prepared from suitable crops of any of the seven chief species of conifer. Strength tests in the laboratory support this experience. They emphasize the need for reasonably straight props and suggest that some care is needed where growth is very fast, especially in Sitka spruce. The Sitka spruce actually tested was found to be practically equal in strength to the imported maritime pine props of the South Wales coalfield. Proper preparation of props should always include trimming to a smooth state, correct dimensions, and if possible removal of the bark and seasoning to some 20 to 30 per cent. moisture content. In practice, price and labour factors sometimes cause props to be supplied and used with the bark still on; but this is not getting the best out of the material.

EXAMPLES OF GOOD USE OF CONIFER THINNINGS.

Two outstanding examples of good use of conifer thinnings may be cited, one by the State and one by private enterprise.

The Forestry Commission has planted in East Anglia, in its Eastern Conservancy (England), a most valuable forest of some 40,000 acres of Scots and Corsican pine, on poor sandy soil above chalk, with a very low rainfall. The central depot for the thinnings from this forest is at Brandon, Suffolk. The volume of valuable produce now passing through this depot is most inspiring. It goes in great quantity both to the coal-mines and to private enterprise in the form of paper-mills, fibre-board factories, wood-wool (excelsior) factories, and the many consumers of agricultural and garden poles and stakes. Already, too, a small but growing proportion of the thinnings is large enough for sawing into boards, whilst the residue goes usefully into fire-wood. The outturn of thinnings of the Eastern Conservancy (England) for the six months October 1950–March 1951 has been distributed as shown opposite.

This is on a sustained yield basis, of course, from a relatively young forest. It is an encouraging example of the first-fruits of the country's belated but now great effort to take forestry seriously.

The policy and price factors in the distribution are outside the scope of this paper, but it is right to point out how valuable is the integration of the uses

to which the thinnings are being put. Straightness is vital in pit-props, as has been shown above. It is of little or no importance in material for pulping or chipping or turning into wood-wool. The alternative markets help the producer to supply straighter cleaner pit-props, for his crooked or rough trees can go elsewhere.

Percentage of total volume		*Cu. ft. hoppus, over bark*
54	Paper-pulp wood, fibre-board mills, and wood-wool	531,000
31	Mining timber	304,000
10	Unselected poles, posts, &c. . .	99,000
5	Round timber and saw-logs . .	44,000
100		

(+121,000 cu. ft. of fire-wood)

The economic benefits of such marketing are great; and silviculture becomes much easier when the forester can sell every stick he wishes to remove, in the interests of better trees or the future crop. The reverse is the case when thinnings are unsaleable, and funds to pay for thinning are hard to find, as the private owner in less happy areas and times had good reason to know.

The other example of good use of conifer thinnings is from Queensferry, near Chester, where Mr. Gordon R. Jacob, of Messrs. J. R. Gordon & Co., is specializing in the production of sawn boards and small-dimension timber for packaging, &c., from very young conifer thinnings of small diameter. His machines, developed with his partner, Mr. Horwood, and his methods have been well illustrated and described in the *Empire Forestry Review* (5) and other journals. The enterprise and timing of Mr. Jacob's efforts have been deservedly admired. When imported conifers are scarce and whilst most of the home-grown conifers are still young and small, after the devastation of two wars, such methods as he has demonstrated are particularly valuable. He combines and integrates them with normal milling, so far as the present short supplies of large trees in the country allow; and he is keenly interested in developing pulp or fibre-board markets for conifer thinnings in areas other than East Anglia, on the lines already described for Brandon.

Finally, it is appropriate to mention here how important a part the treatment of wood with preservatives can play in the proper use of conifer thinnings, especially those which unlike larch are not naturally durable. The Forestry Commission and many private woodland owners or operators in home-grown timber realize this, but much remains to be done in convincing producers and consumers as a whole. The large proportion of perishable sap-wood in thinnings is a major factor in this matter. There is no case for treating pit-props which are required to last only a few days or weeks in use; but there is a good case for treating other forms of mining timber, such as roadway supports, where the use may run into years, in settled ground, if the timber remains sound.

THE ESTIMATED TOTAL VOLUME OF CONIFER THINNINGS AVAILABLE IN GREAT BRITAIN IN 1951 AND 1960–1.

The 1947–9 Census of Woodlands shows that in 1951 there are estimated to be available some 14 million cubic feet, hoppus measure, of conifer thinnings, per annum, under 6 in. quarter girth at breast height, measured over bark, i.e. approximately 8 in. diameter and under. The corresponding figure for 1960–1 is estimated at some 19 million cu. ft. Nearly half of this is in Scotland, and rather more than half in England and Wales. The approximate percentages for species at the present time are as follows, by volume:

	Pines	*Spruces*	*Larches*	*Other conifers*	*Total*
England . .	40	25	25	10	100
Wales . .	10	50	25	15	100
Scotland . .	45	35	15	5	100

The magnitude of these figures is striking and encouraging. As the planting programme continues, and the crops mature, so will the snowball effect on the outturn increase, and forestry's contribution to the national economy grow.

THE EFFECT OF RAPID GROWTH AND PRUNING ON CONIFER WOOD QUALITY AND USE.

This question is important and interesting, and by no means simple. Much depends on what industry will demand decades ahead, which is not easy to estimate. It will be affected, too, by the geneticist or tree-breeder, who may be able to produce, at least in some species, races with relatively light small side-branches, a tendency to early self pruning and a habit of forming relatively dense, strong wood early and fast.

Reference is invited to Mr. Armstrong's article, already cited, on the strength of home-grown pit-props. The tests at Princes Risborough showed that when the annual rings per radial inch fell below 8 for Scots pine or 6 for the six other conifers tested, there was a marked decrease of strength, associated with a lowering of the density of the wood, in these young trees of small diameter. Obviously one must weigh up the value of strength, and the real need for it in the commoner uses expected, against the higher cost in time and money of a slower crop or longer rotation for a given size. Thus Mr. Armstrong found that the home-grown Scots pine tested showed maximum strength at about 20 rings per inch; and it is interesting to note that a recent examination of the wood of an old Scots pine tree from Glenuig, in western Ross-shire, believed to be a remnant of the ancient Caledonian Forest, showed an average of some 23 rings per inch in a life of over 200 years, and a very high density (about 39 lb. per cu. ft., air dry), probably associated with the great strength and durability for which such timber was famous. Yet the economics of growing such a crop today, on any large scale, are probably indefensible, compared with Scots pine or other species grown at twice the rate, or even faster.

South Africa has done classical work on this subject, associated with the names of I. J. Craib, M. H. Scott, R. P. Stephens, and J. M. Turnbull, and their studies of spacing, thinning, pruning, and timber quality in their exotic pine plantations of *Pinus patula*, Schlech and Cham., *P. caribaea* Morelet, *P. radiata* D. Don, &c. They have produced good evidence that in their conditions pine trees of good timber quality can be grown to some 15 in. diameter or more in 35 years; but they aim at a range of 4–8 annual rings per inch, and as even as possible a ring width from pith to bark. (2, 9, 10)

Similarly, in the U.S.A. valuable studies of timber quality in the pitch pines of the south-east have been made by Benson H. Paul and colleagues at the Forest Products Laboratory, Madison. They warn against serious risks of distortion in drying, and other troubles, if the annual rings per inch are below four, especially if, too, the ring width varies greatly from pith to bark in a small- or medium-sized log, so that boards sawn from it will have wide rings on one edge and narrow rings on the other (6, 8). And with the dwindling of the virgin stands of very old Douglas fir on the Pacific coast, and the increasing use of much younger second-growth Douglas fir, great attention is now being given to the relative timber qualities of the two types of tree (7). There is some evidence that for prime face veneers peeled for plywood there is a marked fall in quality at about 10–12 rings per inch, quite independently of knots. On the other hand, this may be in relation to a standard which simply cannot be maintained when the virgin forests have gone, and one which is unnecessarily high. (3)

In Australia and New Zealand, particularly the latter, one of the greatest demonstrations of the success of rapid-growing exotic pines, chiefly *Pinus radiata*, is available. (This species is often called insignis or Monterey pine.) Where it has proved possible to prune, or to select superior races of the species, the benefits in improved timber value appear to have been substantial. Scarcity of alternative imported conifer timber, due to war or economic causes, has helped the sale of *P. radiata* timber, even when knotty and troublesome, specially towards the pith or core, owing to spiral or very rapid or uneven growth. And as in Great Britain today the shortage of the more desirable spruces, for paper pulp, is forcing keen interest in the use of pines for pulp, and great schemes for integrated utilization.

A study of the average density and timber quality of the faster growing exotic conifers in Great Britain, specially Sitka spruce and Japanese larch, is now in hand at the Forest Products Research Laboratory, Princes Risborough, in collaboration with the Forestry Commission and certain private woodland owners. It is hoped to get some important broad results soon, with more detailed results and checks later.

Finally, the case for pruning the side branches of conifers in Great Britain may be considered. If it is done at all it must be whilst the diameter of the main stem is small, preferably under 6 inches, or even 4 inches if possible. Otherwise the layers of clear knotless wood laid on after the pruned stubs heal over will not be wide enough to repay the pruning cost, when the log is sawn up. With all the common conifers except the spruces there seems little risk of fungal disease if live branches are pruned; but with the spruces the evidence from Germany, Sweden,

North America, and Britain itself suggests that it is safer to wait till the side branches die before pruning them. With very vigorous healthy Sitka spruce in western Scotland green pruning may be safe; but even there, dead pruning is still safer.

Opinion in Germany and Scandinavia is divided as to whether pruning conifers will pay. In general it is felt, however, that where the growth and timber are of high quality, and the timber is likely to be wanted for plywood or other exacting markets, pruning will pay. The best common spruce in Germany is said to grow at Westerhof, not very far from Hanoverisch-Münden. It is high pruned, when the branches are dead, and foresters of such repute as Doctors Hilf and Strelke are convinced that this pruning pays handsomely in cash returns. Other German foresters of long experience believe in pruning Douglas fir and Japanese larch but not the ordinary run of common spruce; because the branches of Douglas fir are apt to be very coarse and long persistent, and those of Japanese larch on certain sites very coarse; and because the common uses of ordinary qualities of spruce, not the Westerhof spruce, do not in their opinion merit the cost of pruning to avoid the small knots which are readily tolerated in flooring, packaging, &c.

For Great Britain, then, there is much to be said for a policy on the following lines. To prune when possible only where quality is high, labour and supervision are not too costly, and the probable use of the final crop is such that buyers are likely to be willing to pay adequately for the cleaner wood produced from pruned trees. Machines or special tools may reduce the cost of pruning, as of many other operations; and supervision of pruning is probably easier on small or moderate sized private estates than in much larger State forests. Mr. G. C. Wolryche-Whitmore in Shropshire and Mr. C. P. Ackers in Gloucestershire are well-known exponents of skilful pruning which is likely to pay well.

It is better to aim at as high a timber quality as possible, at least in favourable areas, either by pruning or genetics, or both, than to rely on chemical or pulping developments in which knots may be unimportant. For it remains to be seen how far such developments will replace traditional uses of sawn timber, where knots are a critical factor in many cases.

ACKNOWLEDGEMENTS.

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NOTE.

Since the above paper was prepared and read, there has appeared in the *Empire Forestry Review*, 30, 3, September 1951, a most important and valuable paper by the late M. H. Scott (*Chief Forest Products Officer, Dept. of Forestry, Pretoria*), 'The Quality and Uses of Exotic Softwoods in South Africa'. Reference is invited to that paper for much new information, e.g. the fact that warping in these sawn softwoods is often due to compression wood, rather than fast or uneven growth. The value of the author's work is still clearer from this latest exposition, and clear, too, is the loss to forestry and forest products research by his death. It is to be hoped that others will follow up and develop his work. C. W. S.

NUMERICAL THINNING: WITH SPECIAL REFERENCE TO JAPANESE LARCH

By W. E. HILEY

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(*Paper read before the British Association, August 1951*)

SUMMARY.

A distinction is drawn between qualitative and quantitative, or numerical, methods of describing and specifying thinnings. It is urged that foresters should learn to use numerical specifications and should acquire the technique of thinning to any desired number of trees per acre. If the numbers of trees are plotted against height or age a thinning grade can be represented by a graph. A series of such graphs derived from comparable yield tables for Norway spruce (*Picea abies* Karst.) show that at a height of 70 feet Schwappach recommends the retention of more than three times as many trees to the acre as Møller does. Owing to its intolerance of lateral suppression, Japanese larch (*Larix leptolepis* Gord.) requires heavy and early thinning, and appropriate thinnings for this tree look quite unorthodox. Graphs representing published thinning grades for this tree are reproduced and a provisional thinning specification is presented for Dartington, South Devon, where the average quality class is superfirst of Hummel's yield table.

A GRADE of thinning may be described either qualitatively or quantitatively. An example of a qualitative description is that, in a D-grade thinning, one removes 'all diseased, dead, dying, suppressed, sub-dominant trees and whips and gradually as many as possible of the co-dominants and defective dominants, together with some of the well-formed dominants' (9). Alternatively, as applied to a particular plantation, this thinning might be described by saying that the number of trees per acre is reduced from 1,000 to 600. The latter method of description may be called 'quantitative' or 'numerical'.

The qualitative method is more usual in Britain and it is the method which I learnt and taught. I thought that it should be possible to judge whether a thinning had been done well or badly by looking at it. However, my confidence in being able to judge the suitability of a thinning on qualitative grounds was shattered by finding that Japanese larch in south-west England, when thinned as I thought suitably, required a further thinning in the following year. And, as this frequently proved impossible, nearly all our Japanese larch plantations became under-thinned. If thinnings were to last 3 years, as is required by our thinning schedule, they had to be so heavy that they looked quite wrong according to my previous standards.

When I visited South Africa in 1947 I found that fast-growing pines were there being thinned according to a numerical prescription prepared by Dr. I. J. Craib (1). Thus, quality I *Pinus patula* was planted at 9×9 feet (530 per acre) and the number of trees per acre was reduced to 300 at 8 years, 200 at 12 years, and 130 at 18 years; they were to be clear-felled at 30 years. Foresters were trained

to mark a square chain and scribe the appropriate number of trees in this one-tenth acre to reduce them to the required number, and to continue thinning in the same way. This is easy with *P. patula* as the trees grow evenly and straight; and all those which are left at each thinning are dominants or co-dominants.

Such a prescription appears inelastic, but the results of using it were far better than our results with Japanese larch. And it is noteworthy that, when dealing with plantations of *P. radiata* on poor soils in South Australia, N. W. Jolly (8), who is critical of Craib's heavy thinnings, nevertheless adopts the quantitative method in describing his thinnings and in making recommendations.

The urge to use the quantitative method of describing thinnings has arisen, in my case, from the difficulty of handling very fast growing species, since with many of these I find it necessary to thin in a manner which is outside our traditional experience. The type of thinning which the Forestry Commission now designates as 'E-grade thinning' appears, however, to be quite suitable for Japanese larch. The specification of an E-grade thinning is 'Reduce stocking to about two-thirds of that in a D Grade',[1] and if, as appears doubtful to me, this description is sufficiently clear, it is unnecessary to prescribe any definite number of trees per acre. Nevertheless, I think the numerical method has definite advantages.

One advantage is that it is easy to learn. Any intelligent foreman can follow thinning instructions if expressed in a numerical form, even if he has not previously thinned to that grade. I found in South Africa that farmers who had had no forest training were getting better results by following Craib's prescriptions than most British foresters obtain by using traditional methods; and I have come to doubt whether thinning is such a skilled craft as many of us think.

This does not mean that the thinning can be mechanical. As much discernment must be used in selecting the trees which should be retained as in a qualitative thinning. But the pernicious results of bad thinning are due less to taking the wrong trees than to taking too few or too many. It is fairly easy to learn to distinguish a good tree from a bad one, but it takes years of experience to learn how heavily to thin. And if, after long experience, those who have made a special study of thinning can lay down numerical specifications, a young forester can soon learn to follow them. Also, numerical specifications provide the most hopeful means of breaking the tradition of under-thinning which is so common in British plantations, especially those on private estates. When foresters acquire the habit of estimating the numbers of trees per acre in their plantations and comparing them with modern specifications they will begin to realize how dense their plantations are; and they may then learn to thin more heavily.

Another advantage of the numerical method is that it makes it possible to compare different thinning grades. If all the thinnings, from the first thinning up to final felling, are recorded numerically, the figures give a clear picture of the method of cultivation. The numbers per acre may be graphed against either age or height and the resulting curve becomes a simple expression of a thinning grade. Let us consider for a moment whether, if the abscissae are numbers of trees per acre, the ordinates should be age or height.

[1] Communication from Forestry Commission.

It is clear that the speed with which the number of trees should be reduced will be determined by height growth rather than by age; the faster the trees are growing the more quickly they must be thinned. We do not know, however, that a slow-growing plantation of any species, when 50 feet high, should have the same number of trees as a fast-growing plantation, when 50 feet high. In nearly all published yield tables the lower quality classes have fewer trees per acre at any given height than the higher quality classes, though they have more trees at any given age. An exception to this is Møller's Danish table for Norway spruce (11) which has about the same number of trees at the same height for all quality classes. So, even if the number of trees is graphed against height, the curve may only apply to one quality class; and if a different curve must be drawn for each quality class, it makes little difference whether the ordinates are age or height.

A graph based on age rather than height is the more convenient for administrative purposes. For instance, at Dartington our Japanese larch averages quality super-first of Hummel's recent yield table (7), though some belong to first quality and a few to super-super-first. As the rate of growth is fairly constant, it seems reasonable to lay down a table of thinning for foremen showing the number of trees to be left at each age rather than each height, and this avoids the trouble of estimating heights and fits in with a regular thinning schedule.

To give a true picture of a thinning grade a graph should be drawn in steps as shown in Fig. 1. The vertical lines represent the reductions in the numbers of trees at each thinning, and the horizontal lines the increase in age (or height) that occurs between the thinnings. If the graph is smoothed through such a series of steps, it is open to question whether the smoothed curve should be drawn through the points a_1, a_2, a_3,... (i.e. the number of trees left after thinning), or through the points b_1, b_2, b_3,... (i.e. the number of trees immediately before thinning). The former is clearer as a thinning prescription, but the latter is useful since it indicates the density at which a thinning is considered necessary. For certain purposes the middle line between these two is the best since it shows the *average* number of trees per acre which will be present in the forest at each age (or height). In Fig. 2 this method has been followed since Møller's graph (11) is published in this form and it was easier to convert the other yield tables to average numbers than to inject thinning steps into Møller's graph.

An example of the graphical method of comparing thinning grades is shown in Fig. 2. This figure has been prepared for Norway spruce and shows the average number of trees per acre at each height, according to British Yield Tables (2, 4) quality II and according to yield tables prepared by other authors for spruce with approximately the same rate of height growth. It also shows the new figures published by the Forestry Commission in the revised edition of *The Thinning of Plantations*[1] (5). As explained in the previous paragraph, the graphs have been adjusted to show heights half-way between one thinning and the next.

[1] In drawing this graph top heights were converted to mean heights according to graphs kindly lent me by the Forestry Commission; and thinning steps were introduced on the assumption that the plantation was thinned at every 5-foot interval in top height.

The most startling feature disclosed by this graph is the extraordinary lack of agreement between the various authors, and this is certainly due more to individual tradition and preference than to different geographical requirements. Thus at a height of 70 feet Schwappach (12) in Germany recommends between three and four times as many trees to the acre as Møller in Denmark. It may fortify a

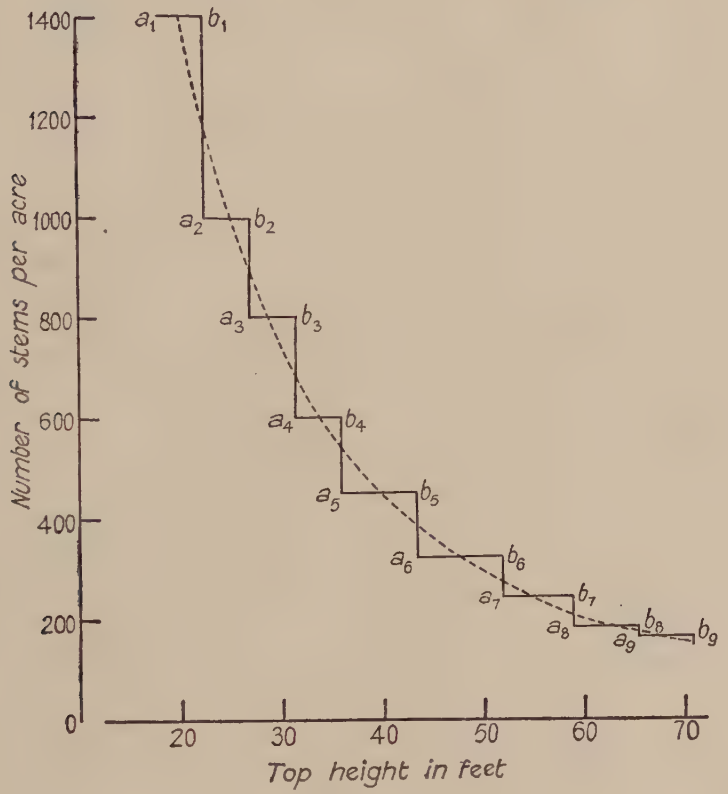

Fig. 1

forester to know that if, at this height, he has anything between 200 and 650 trees per acre he can claim the support of very high authority.

The graphs show a rapid change in opinion about thinning during the last half-century. Schwappach, whose tables were first published in 1912, was deeply shocked at the relatively heavy thinnings suggested by the British Yield Tables (1920). Indeed he ascribed the heavy early thinnings to sporting rather than silvicultural reasons so as 'to facilitate beating for rabbits and pheasants'.[1] And yet nearly all foresters now regard the thinning grade shown in the British Yield Tables as being far too light, and the figures now recommended by the Forestry Commission are more in keeping with modern practice. Møller's table is based on

[1] Quoted by Gehrhardt (6).

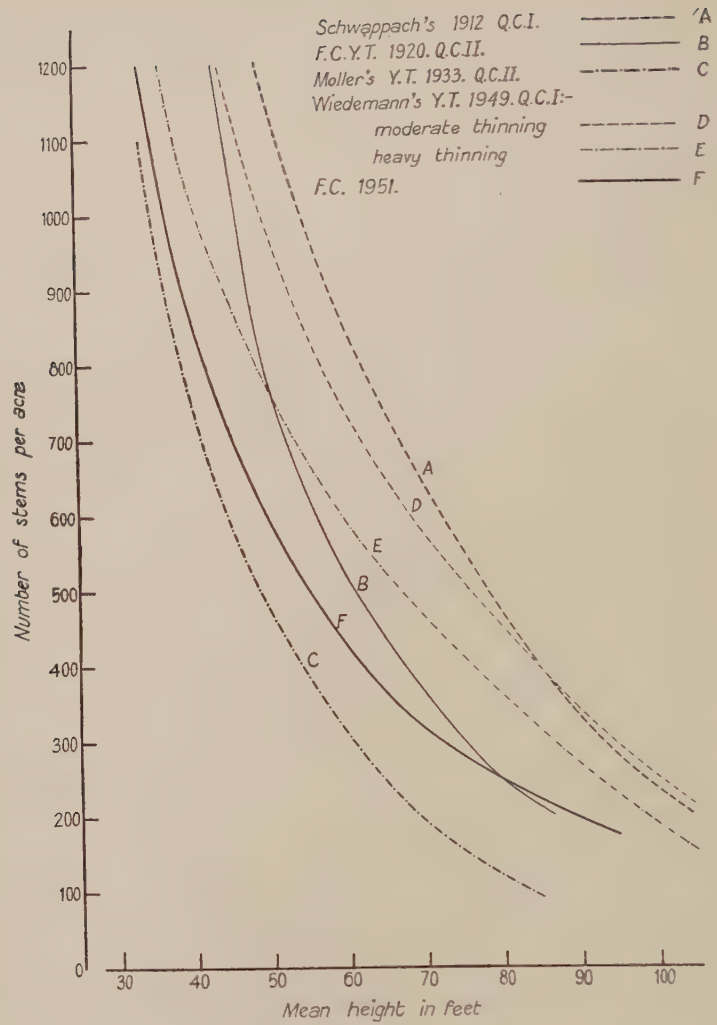

Fig. 2

a far heavier thinning than this and represents the technique which has been successfully developed in Denmark.

A THINNING GRADE FOR JAPANESE LARCH, QUALITY CLASS SUPER-I.

Japanese larch is one of the most difficult species to thin effectively. It grows extremely fast and nearly all the plantations I have seen in Britain appear drawn; the stems are thin for their height and the crowns are small; and we have experience that, if such drawn trees are thinned heavily in later years, the crowns fail to respond and growth becomes extremely slow. The best timber trees of this species which I have seen in Britain have been grown in European larch plantations

which were sparingly beaten up with Japanese larch. The Japs outgrew the European and, as they had little competition, the crowns became sufficiently large to feed the stems. The finest Japanese larch I have ever seen are in the Danish

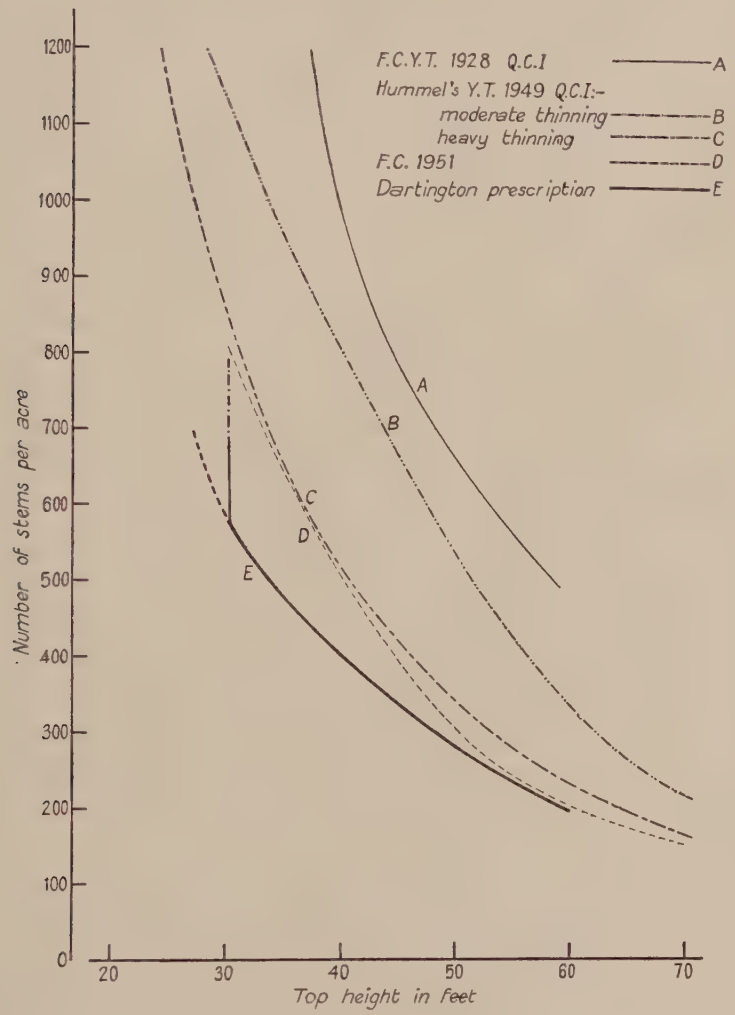

FIG. 3

forest, Bjergsted Skov, belonging to Baron Christian Schaffalitzky de Muckadell, who believes in thinning very heavily indeed. He likes to reduce the number of trees to 80 per acre at 25 years and 40 per acre at 40 years,[1] and hopes by this means to grow fairly large saw-timber on a rotation of 50 years. One of his trees (Pl. I), at an age of 42 years, was 89 feet high, 14¼ inches q.g.b.h., and measured

[1] Personal letter to author.

about 53 c.f.o.b. This method of cultivation demands an undercrop, and at Bjergsted Skov there is a beautiful plantation, 25 years old, in which 40 Japanese larch per acre are standing clear of a dense understory of beech which were planted at the same time.

As we have a good market for larch poles of 6–8 inches q.g.b.h., we may find at Dartington that our best method of growing Japanese larch timber is to thin very heavily (perhaps to 60 to 80 trees per acre) at 25 years and underplant with a shade-bearer. Our plantations are not yet old enough for this and our object in the meantime is to grow trees which are sufficiently vigorous, heavy-crowned, and wind-firm to respond to such treatment. We have no reason to think that a thinning specification which will meet this need should not be applied, at any rate up to 20 years, to plantations which are to be grown to maturity as pure larch.

We have at Dartington no permanent sample plots of Japanese larch which are old enough to demonstrate a correct method of thinning. We have intentionally applied heavy thinnings in our plantations, but in nearly all of them we now wish that we had thinned even more heavily. The plots which look most satisfactory, at an age of 15 to 20 years, are those in which the plants were widely spaced from the beginning, either as the result of admixture with slower growing species or because of early losses. If the trees have been planted at 6 by 6 feet (1,210 per acre) a heavy thinning is required at 10 years, and it seems safer to plant at 8 by 8 feet (680 per acre) when the first thinning may not be necessary until about the 12th year. Since the number of trees will have been reduced to about 250 per acre by the 20th year, this leaves reasonable latitude for the removal of badly shaped trees.

Fig. 3 shows thinning grades (numbers after thinning) for Japanese larch, quality I, which have been published in Britain. Graph A shows the figures from the earlier Forestry Commission Yield Tables (3, 4), corrected from mean height to top height. Graph B represents Hummel's 1949 (7) 'moderate' thinnings, which are closely related with tables published by J. Macdonald in 1935 (10). Graph C depicts Hummel's 1949 'heavy' thinnings, graph D the Forestry Commission's 1951 recommendations (5), and graph E shows the proposed Dartington specification for quality class super-I.

The proposed Dartington specification may be compared with the E thinnings carried out by the Forestry Commission in permanent sample plots in Devon and Cornwall, the figures for which are shown in Table I.

In each set the last thinning was made in the winter of 1950/1, so insufficient time has elapsed to show results. Both the Okehampton plots were looking very satisfactory and the trees had good crowns; I thought the C/D thinning would require thinning again in about 2 years and the E thinning (Pl. II) in about 4 years. The remainder of the plantation, which had not been thinned by the Research Staff, was far inferior. Neither of the Cardinham plots looked right since in each case the crowns were small and damaged. This could be accounted for by close planting with delayed early thinning. But the E thinning was far more promising than the D thinning, and the trees in a neighbouring C thinning were already ruined.

TABLE I. *Thinning Grades for Japanese Larch at Okehampton and Cardinham Forests*

	Age	Top height	Number of trees reduced	
			from	to
Okehampton				
Plot E 215. C/D thinning.	17	33	1,043	693
	20	38	693	482
Plot E 216. E thinning.	17	32	1,189	565
	20	37½	565	340
Cardinham				
Plot E 196. D thinning.	13	32	1,401	822
	16	35½	822	511
Plot E 197. E thinning.	13	32½	1,406	666
	16	36½	666	419

It will be seen that, at a height of 35 to 40 feet, the proposed thinning specification for Dartington lies between the D and E thinnings of the Forestry Commission but that our thinning starts much earlier than theirs. This early thinning ensures vigorous crowns and enables us to remove badly shaped trees before they have done irretrievable damage to their neighbours. We hope, too, that, if this heavy thinning schedule is followed, the thinning period can be lengthened to 4 years. To get the best results the trees should be pruned.

The thinning specification is set out in Table II. The figures show the number of trees per acre which should be left at each age, and it is hoped that, if the first

TABLE II. *Proposed Thinning Grade for Japanese Larch Quality Class Super-first at Dartington*

(Planted at 6×6 ft.)

Age	Top height	No. of trees after thinning	No. of trees removed in thinning on a 4-year thinning period
Years	Feet		
8	25	Say, 1,000	..
10	30	560	440
12	35	470	..
14	40	400	160
16	45	340	..
18	49	290	110
20	53	250	..
22	57	215	75
24	60	190	..

thinning is carried out in the 10th year where the planting distance was 6 feet, and in the 12th year where the planting distance was 8 feet, a subsequent thinning will not be required until 4 years later. Recent measurements suggest that, in plantations in which heavy thinning has started as early as this, the numbers of trees may be reduced rather more rapidly than is indicated in the table. At a height of 50 feet 250 trees to the acre appear to be sufficient.

Plantations of fast-growing Japanese larch, which have been insufficiently thinned while they are young, do not respond readily to opening up in later years and any treatment which is applied to such plantations must be rather experimental. The safest treatment is to thin them moderately every year until the number of trees has been reduced to the desired extent; but, partly owing to the fact that the trees are 'whippy' and crash into each other even in light winds, the crowns may continue to be narrow and unsatisfactory and the diameter increment of the stems may still be meagre. If there is a sufficient number of large-crowned trees it may be better to isolate about 60 to 80 of these to the acre and underplant with some shade-bearing species. But, if the crowns are not sufficiently vigorous, the trees may fail to respond to this treatment, in which case the wisest course is usually to clear-fell the plantation and start again.

ACKNOWLEDGEMENT.

This paper is published with the permission of the British Association for the Advancement of Science. The graphs were prepared for me by Mr. R. Lehtpere.

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Japanese larch. 42 years. 89 ft. high, $14\frac{1}{4}''$ q.g.b.h. 30 trees per acre. Bjergsted Skov, Denmark. Photo by author, 1950

PLATE I

Japanese larch. 20 years. Top height 37½ ft. E thinning at 17 and 20 years. 340 per acre. Forestry Commission Sample Plot E 216, Okehampton, Devon. Photo by author, 1951

PLATE II

AN EXPERIMENT ON THE SAMPLING OF EARLY THINNINGS

By F. C. HUMMEL

Mensuration Officer, Forestry Commission

SUMMARY.

Several subjective and objective methods of sampling the average volume per tree in first and second thinnings were tested in stands of Sitka spruce (*Picea sitchensis* Carr.), Norway spruce (*Picea abies* Karst.), Scots pine (*Pinus sylvestris* L.), Corsican pine (*Pinus nigra* var. *calabrica* Schneid.), Douglas fir (*Pseudotsuga taxifolia* Brit.), and European larch (*Larix decidua* Mill.). Altogether 7,000 thinnings were measured at Fernworthy in Devon, Thetford Chase in Norfolk, Forest of Ae in Dumfriesshire, and Kinellar in Aberdeenshire. The subjective methods, consisting of visual estimates and the measurement of groups of trees selected as appearing representative, tended to give biased results no more precise than those obtained by the objective methods which are unbiased. The objective methods tested were random groups, systematic sampling by trees, and systematic sampling by rows. The systematic sampling by rows was the most satisfactory in combining a reasonable degree of precision with simplicity in execution.

IN a large-scale thinning operation it costs much time and money to determine the volume of every pole. If conversion into pit wood or other produce is carried out immediately after felling in the forest, the need for measuring individual poles before conversion does not arise, because the converted produce can be taken as the basis for paying for the felling and conversion at piece-work rates, for selling the produce, and for maintaining adequate forest records. If, on the other hand, poles are extracted without having been converted, their volumes must be determined before they are removed from the forest. Unless, however, a very high degree of accuracy is called for this will not usually necessitate the measurement of every pole but only of an adequate and representative sample.

The objects of this experiment were, first, to determine the most efficient method of sampling small thinnings, the most efficient method being that which can be relied upon to give a volume estimate of specified precision at minimum cost in time and effort; and, secondly, to determine the sampling intensity required to obtain that specified precision.

METHOD.

The method adopted was to select compartments in which ordinary thinnings had been marked by the local staff, and to number all the trees marked for thinnings in a 5- or 6-acre plot within these compartments. These plots were subdivided into 1-acre sub-plots. By measuring all the thinnings in the 5- to 6-acre plot, after they had been felled, the actual mean volume per thinning was determined and compared with the volume obtained by the methods and intensities of sampling listed below.

1. *Ocular estimates*

As many foresters as could be made available on each site were asked to record what they considered the mean volume per thinning after going through the plot when the thinnings had been marked, but not yet felled. (At Fernworthy there were 37 foresters, at Thetford 18, at the Forest of Ae 12, and Kinellar 12.)

2. *Selected groups of 10 trees*

The same foresters were each asked to select groups of 10 trees marked for thinnings—one group in each of the five or six 1-acre sub-plots. They selected a thinning which they considered to be approximately of average size as the centre tree of each group, and they recorded its number, together with the numbers of the nearest nine thinnings around it. The mean volume of the 50 or 60 trees thus selected was the mean of the sample. The selection of the groups was carried out before felling, but the volumes of the thinnings in them measured after felling. This presented no difficulty as all the trees had numbers painted on them. In one locality (Thetford) in addition to the selected groups of 10 trees each forester was also asked to select independently 50 single trees which he considered representative. This method is said to have been customary in part of that area.

3. *Random groups of trees*

(i) Groups of 5 trees.
(ii) Groups of 10 trees.
(iii) Groups of 20 trees.

One tree in each sub-plot was chosen at random, i.e. by picking a number from the list instead of by selection on the ground as under method 2. This tree was taken as the centre of the group of 5 trees, as well as of the groups of 10 and 20 trees. In plots where there were six 1-acre sub-plots:

(i) gave a sample of $6 \times 5 = 30$ trees.
(ii) „ „ „ „ $6 \times 10 = 60$ trees (same intensity as method 2).
(iii) „ „ „ „ $6 \times 20 = 120$ trees.

A very large number of possible samples exists under this method, of which 10 were chosen at random for analysis.

4. *Systematic sampling by rows*

(i) Every thinning in every 5th row (i.e. 20 per cent. sample).
(ii) „ „ „ „ 10th row (i.e. 10 per cent. sample).
(iii) „ „ „ „ 30th row (i.e. 3·3 per cent. sample).

5. *Systematic sampling by trees*

(i) Every 5th thinning in every row (i.e. 20 per cent. sample).
(ii) Every 10th „ „ „ „ (i.e. 10 per cent. sample).
(iii) Every 30th „ „ „ „ (i.e. 3·3 per cent. sample).
(iv) Every 50th „ „ „ „ (i.e. 2 per cent. sample).
(10 of the 50 possible combinations were calculated.)

It will be observed that the first three intensities in methods 4 and 5 are identical, the difference being merely in the distribution of the sample over the area.

REPLICATIONS.

Age and condition of the crop as well as the local factors are likely to affect the issue. The experiment was confined to first and second thinnings, but it was repeated in four fairly widely separated forests:

1. Fernworthy (South-West Conservancy, England), compartments 2 and 36.
2. Thetford Chase, High Lodge beat (East Conservancy, England), compartments 29 and 173.
3. Forest of Ae (South Conservancy, Scotland), compartment 31.
4. Kinellar (East Conservancy, Scotland), compartment 17.

The species examined were Sitka spruce and a mixture of Sitka spruce and Douglas fir at Fernworthy; Scots and Corsican pine at Thetford; Sitka spruce at Forest of Ae, while at Kinellar there were sub-plots of Norway spruce, European larch, and Douglas fir all in the same 5-acre plot.

DEFINITIONS.

The details of measuring procedure were slightly varied in the different localities to suit local custom. In every case, however, measurement was to a top of 3 inches diameter over bark, but where there was a market for produce between 3 inches and $1\frac{1}{2}$ inches diameter, an allowance of 0·2 hoppus feet was added to the volume of each tree in respect of this. At Thetford trees with a butt diameter of less than 4 inches were taken at 0·4 hoppus feet. Very small trees that were obviously quite useless were not counted.

Before giving the results in detail it is necessary to define clearly two terms:

Bias refers to the tendency of sampling errors to be mostly in one direction. It is the difference between the average of the sample values that would be obtained in an infinitely large number of repetitions of a sampling process and the population mean.

Precision describes the degree of concentration of estimates about their mean value in repeated sampling.

The following examples from compartment 2 at Fernworthy will illustrate these definitions.

(i) *Every 5th tree*: there are 5 possible samples giving mean volumes ranging between 0·679 and 0·731 hoppus feet with an overall mean of 0·714 hoppus feet, which is the true mean. This method is *precise* and *unbiased*.

(ii) *Every 50th tree*: the 10 samples taken range between 0·474 and 0·875 hoppus feet with an overall mean of 0·724 hoppus feet for the 10 samples combined. This method is *not* precise but it is *unbiased*.

(iii) *Single visual estimate*: the 37 estimates given range between 0·50 and 1·75 hoppus feet, and averaged 0·972 hoppus feet, while the true mean is 0·714 hoppus feet. This result is not *precise* and very *biased*.

RESULTS.

The precision obtained by the various sampling methods is given in Figs. 1 to 10, while the presence or absence of bias is indicated in Table I. Figs. 1 and 2 relate to the two plots at Fernworthy, 3 and 4 to the two plots at Thetford, and Fig. 5 to the plot at Ae, while Figs. 6 to 10 are in respect of the five 1-acre sub-plots at Kinellar. At Kinellar it was necessary to deal with each 1-acre sub-plot separately because they differed from one another in species or in age. The individual points in these figures show the variation coefficients obtained by each method at the sampling intensities that were tested. If a given sampling process is repeated, an error exceeding the value of the variation coefficient may be expected in approximately one case out of every three, and an error of more than twice the variation coefficient may be expected in approximately one case in every twenty. The curves in Figs. 1–10 represent the equation:

$$C = k\sqrt{\left(\frac{N-n}{Nn}\right)}, \text{ where}$$

C is the variation coefficient,

n is the number of poles in the sample,

N is the total number of poles in the plot (sub-plot at Kinellar), and k is a constant.

The upper curve (continuous line) is for value $k = 100$ and the lower curve (dotted line) is for value $k = 50$.

It will be observed that the experimental results for the two systematic sampling methods correspond fairly closely to the above equation. The only marked exception is the Scots pine plot at Thetford where, in the sampling by rows, increases in the sampling intensity were not accompanied by the expected reduction in the variation coefficient. This suggests a systematic periodicity coinciding with every fifth row (Finney, 1948 (1, 2)).

An inspection of the graphs also suggests that at Fernworthy, Thetford, and in three of the sub-plots at Kinellar the value of k is approximately 100, while at the Forest of Ae and in two of the sub-plots at Kinellar the variation in volume between individual thinnings is less, and k approximates to the value of 50.

The presence or absence of bias is shown in Table I by expressing the difference between the mean volume of all samples taken by a given method at a specified intensity and the actual mean volume of all the poles in the plot (sub-plot at Kinellar) as a percentage of this actual mean volume. Differences which are significant at the 5 per cent. probability level are marked with one asterisk, and those which are significant at the 1 per cent. level are marked with two.

Dealing with the five methods in turn, the main points to emerge from the data are these:

1. *Ocular estimate.* In 5 cases out of 10, the ocular estimates were significantly biased. The estimates were most precise in the Sitka spruce plot at Ae and the

TABLE I. *The Bias of the Sampling Methods*

Locality	*Fernworthy*		*Thetford*		*Forest of Ae*	*Kinellar*				
						17				
Compartment No. . .	*2*	*36*	*29*	*173*	*31*	*Sub-plot I*	*Sub-plot II*	*Sub-plot III*	*Sub-plot IV*	*Sub-plot V*
Area (acres) . . .	6	5	6	6	6	1	1	1	1	1
Species	Sitka spruce and Douglas fir	Sitka spruce	Corsican pine	Scots pine	Sitka spruce	European larch	Norway spruce	European larch	Douglas fir	Douglas fir
No. of thinnings . .	1,679	587	779	1,711	1,946	195	83	158	116	101
Actual mean volume (hoppus feet O.B.) .	0·714	2·098	1·89	1·38	0·966	1·116	2·478	1·503	2·222	1·896
Method of sampling	*Percentage difference of the mean of all samples from actual mean volume* (*indicates significance at 5% probability and † at 1% probability)									
1. Single visual (%) .	36·13†	9·58†	−11·80†	−4·49	1·97†	−7·89	6·98	−17·63†	16·61	8·86
2. Mean of selected groups of poles (%) . .	2·24	9·34†	−2·48	7·14	8·59*	10·75*	13·44†	7·39	8·64	−1·42
2a. Mean of 50 selected poles (%) . . .	Not applied		12·38†	19·71†	Not applied					
3. Random sampling (%)										
(i) Groups of 5 trees .	−11·06†	4·19	3·42	−8·77	−3·52	7·97	16·38	2·53	−14·22	−39·98†
(ii) Groups of 10 trees.	−6·44*	9·49	1·42	−6·06	−5·49	12·01	14·65†	3·73	−0·09	−31·38†
(iii) Groups of 20 trees.	−4·20	13·39†	2·06	−2·17	−3·21	8·51	3·87	1·06	−9·95	−20·36†
4. Systematic sampling by rows, all intensities 5. „ „ „ trees, „	*Unbiased, differences are zero*									

Norway spruce sub-plot at Kinellar where the variation coefficients were 10 and 12 per cent. respectively; they were reasonably precise in the Scots and Corsican pine plots at Thetford where they were 13 and 16 per cent. In the pure Sitka spruce at Fernworthy the variation coefficient was 18 per cent.; in the European larch sub-plots at Kinellar, 23 and 28 per cent. respectively, and in the three areas of Douglas fir or Douglas fir mixed with Sitka spruce they were 36 to 38 per cent. The trend of the results suggests that precision and freedom from bias in ocular estimates depends on the experience of a forester and his knowledge of the particular locality, as well as on the species—mixtures and Douglas fir appear particularly difficult to estimate.

2. *Selected groups.* Sampling by selected groups was significantly biased in 4 cases out of 10, and the local version of the selected group method which is said to be in use at Thetford gave a highly significant bias in both the compartments where it was employed (instead of selecting groups of 10 trees around an arbitrarily chosen centre tree, each tree is selected individually). Compared with the objective sampling methods, at the equivalent sampling intensity there was on the whole no gain in precision, and compared with the visual estimates the gain was usually not great.

3. *Random groups.* The random group method, as well as the two methods which follow, are objective in contrast to methods 1 and 2 which are subjective. Although every precaution was taken to obtain truly random samples, analysis of the results showed a significant bias in both compartments at Fernworthy and in two of the sub-plots at Kinellar. The reason for this is not understood, but the result shows up very clearly the difficulty of obtaining true randomization in practice. The precision of this method was, on the whole, lower than that of the systematic sampling methods, but the difference was usually small, and there were instances where random sampling actually showed a higher degree of precision than the systematic sampling by trees or rows.

4. *The systematic sampling by rows and by trees.* Both these methods are unbiased as they are free from the influence of personal judgement. On theoretical grounds the sampling by trees may be expected to give slightly more precise estimates than the sampling by rows, because the sample is more evenly spaced throughout the area. The results of the experiment confirmed this, but sampling by trees gave only slightly more precise results than the sampling by rows in the four plots at Thetford and Fernworthy where sampling by rows was tested. In the other areas this method was not applied because there were no distinct rows.

CONCLUSIONS.

1. Ocular estimates are clearly undesirable as a general practice, although individual foresters may, with practice, achieve consistently accurate results, and every forester should in fact be encouraged to develop this faculty.

2. The method of selected groups entails the same risk of bias as ocular estimates and has no apparent advantage in precision over the objective methods. It therefore has little to recommend it.

3. The main drawback of the random group method is that it is difficult to achieve in practice. It is probable that the strict rules of randomization will be violated unintentionally, and this at once introduces the possibility of bias. Moreover, this method, if anything, is less precise than the other objective methods using a systematic sample.

4. Quite clearly the systematic sampling by trees or by rows has shown itself superior to the other methods used, in being free from bias and achieving a greater degree of precision. In choosing between these two methods, the slight advantage in precision of sampling by trees must be weighed against the practical disadvantage of having the sample scattered throughout the wood, and the difficulty, if not impossibility, of ensuring that trees which appear small are not purposely omitted. Where there are no distinct rows, as was the case in the Forest of Ae and at Kinellar, taking all trees along more or less straight lines at fixed intervals should give much the same results.

The results are undoubtedly disappointing in showing that the methods of sampling that were tested give a lower degree of precision than had been hoped. Two points must, however, be borne in mind. First, this investigation was confined to first and second thinnings in stands that were, if anything, less uniform than the average. Sampling of early thinnings in more uniform stands, and sampling of subsequent thinnings even in fairly irregular stands, is likely to produce sampling errors up to 50 per cent. less than those obtained in this experiment. Secondly, in a sequence of thinning operations, individual sampling errors will tend to cancel each other out, provided that the method is objective, so that even if the degree of precision in each operation is low, the overall error in a forest at the end of a year is likely to be small. Neither employer nor employee will therefore lose in the long run if piece-work rates are paid on such objective low-precision sampling, but there will be fluctuations either way in the weekly payments that do not correspond to the fluctuations in the amount of work done. The main question is to decide on the maximum fluctuations of this kind that should be accepted. In deciding this point it must be remembered that increasing the sampling fraction will only be worth while if a high standard of accuracy in measurement can be maintained. A complete measurement badly done may produce worse errors than sampling in a carefully measured sample.

Table II below gives an approximate indication of the size of sample and of the sampling fraction required under systematic sampling by rows to give estimates within specified limits for varying total numbers of thinnings under conditions approximating those of this experiment. The errors are calculated by the formula given previously:

$$C = k\sqrt{\left(\frac{N-n}{Nn}\right)}; \text{ for } k = 100.$$

Under these conditions errors exceeding the fiducial range of error given in Table II may be expected in approximately one case out of every twenty, and errors half as large in one case out of every three.

TABLE II

*Fiducial range of error**	*Number in sample (sampling fraction) required for populations of*				
	100	*500*	*1,000*	*5,000*	*10,000*
1%	95($\frac{1}{1}$)	450($\frac{1}{1}$)	830($\frac{1}{1}$)	3,450($\frac{1}{1}$)	6,000($\frac{1}{2}$)
5%	78($\frac{1}{1}$)	320($\frac{1}{2}$)	470($\frac{1}{2}$)	1,000($\frac{1}{5}$)	1,200($\frac{1}{8}$)
10%	60($\frac{1}{2}$)	170($\frac{1}{3}$)	230($\frac{1}{4}$)	330($\frac{1}{15}$)	360($\frac{1}{28}$)
15%	44($\frac{1}{2}$)	105($\frac{1}{5}$)	130($\frac{1}{8}$)	160($\frac{1}{31}$)	170($\frac{1}{59}$)
20%	37($\frac{1}{3}$)	70($\frac{1}{7}$)	80($\frac{1}{12}$)	90($\frac{1}{56}$)	90($\frac{1}{111}$)
25%	30($\frac{1}{3}$)	50($\frac{1}{10}$)	55($\frac{1}{18}$)	60($\frac{1}{83}$)	60($\frac{1}{167}$)
30%	25($\frac{1}{4}$)	35($\frac{1}{14}$)	40($\frac{1}{25}$)	40($\frac{1}{125}$)	40($\frac{1}{250}$)

* There is a probability of approximately 20 to 1 against a sampling error exceeding the fiducial range of error.

ACKNOWLEDGEMENTS.

I am much indebted to the Forest Officers and Foresters who took part in the estimating tests or helped in other ways, and particularly to Mr. W. T. Waters, who was in charge of the field work, and Mr. J. Jeffers, who analysed the data.

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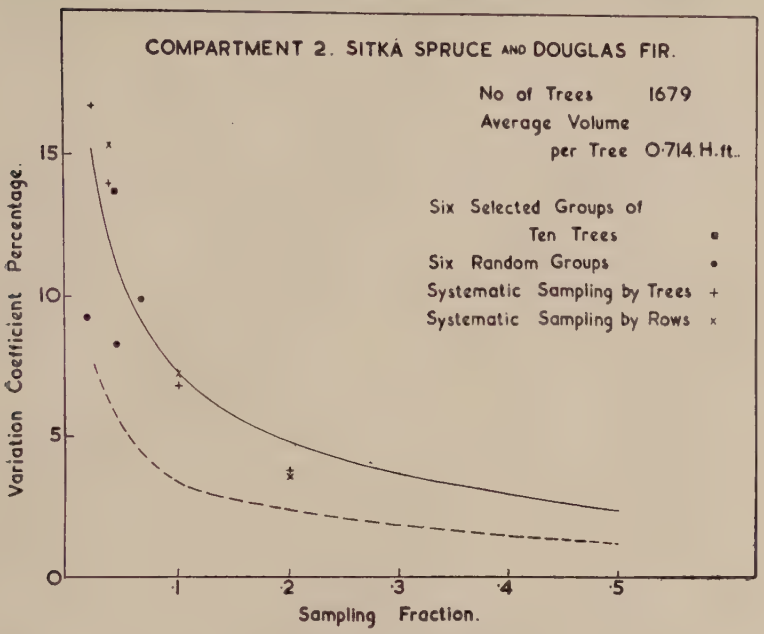


FIG. 1. Fernworthy

NOTE.—The variation coefficient of the visual estimate is 39 per cent. in Fig. 1

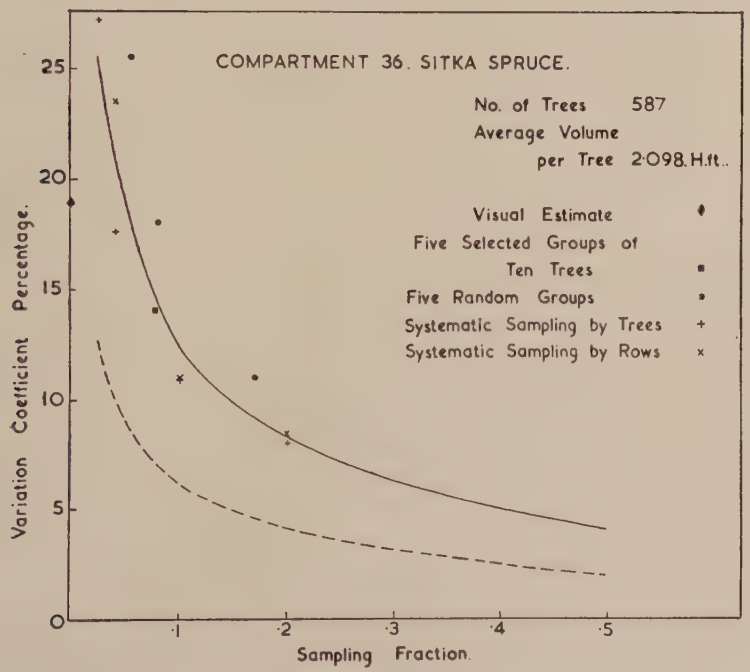
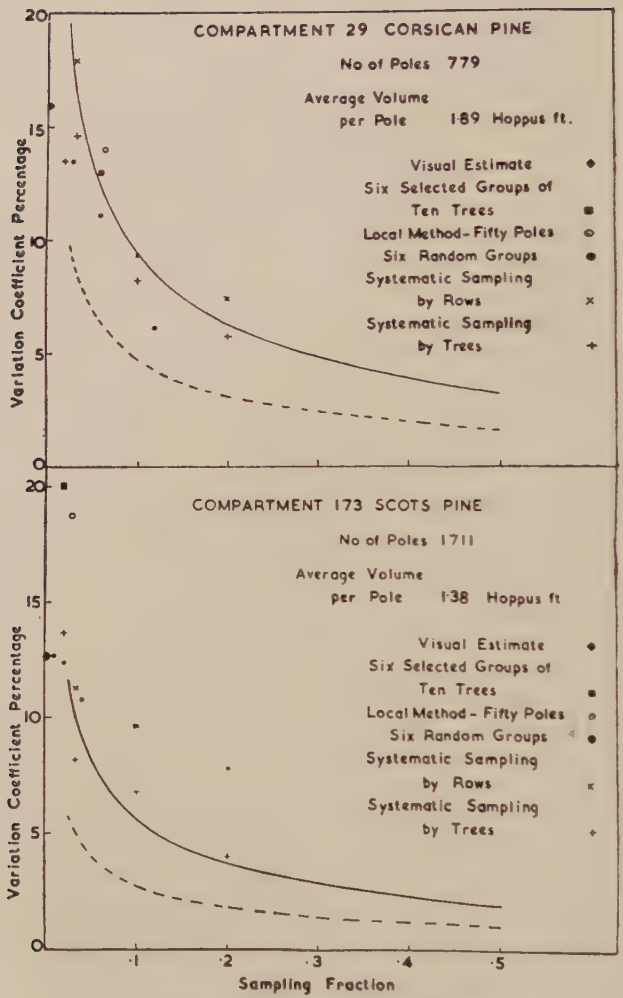


FIG. 2. Fernworthy



FIGS. 3 and 4. Thetford High Lodge

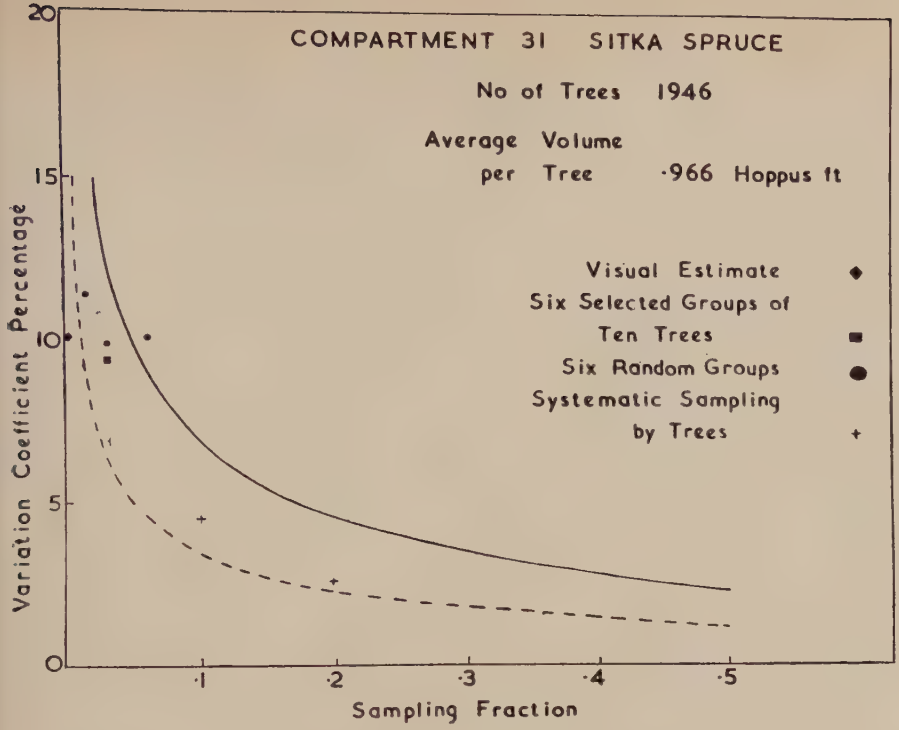


FIG. 5. Forest of Ae

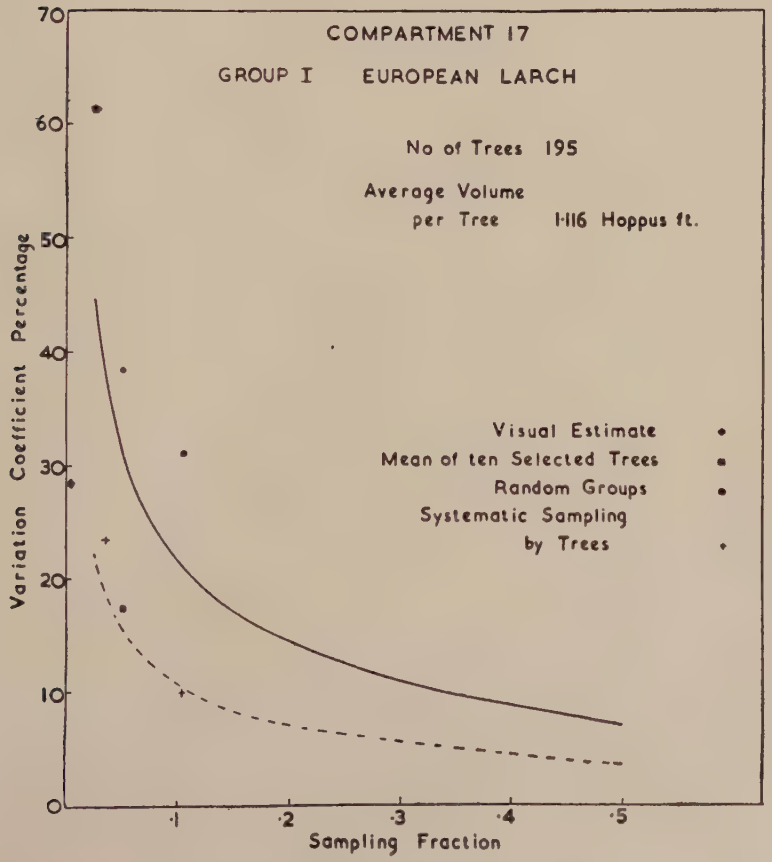


FIG. 6. Kinellar

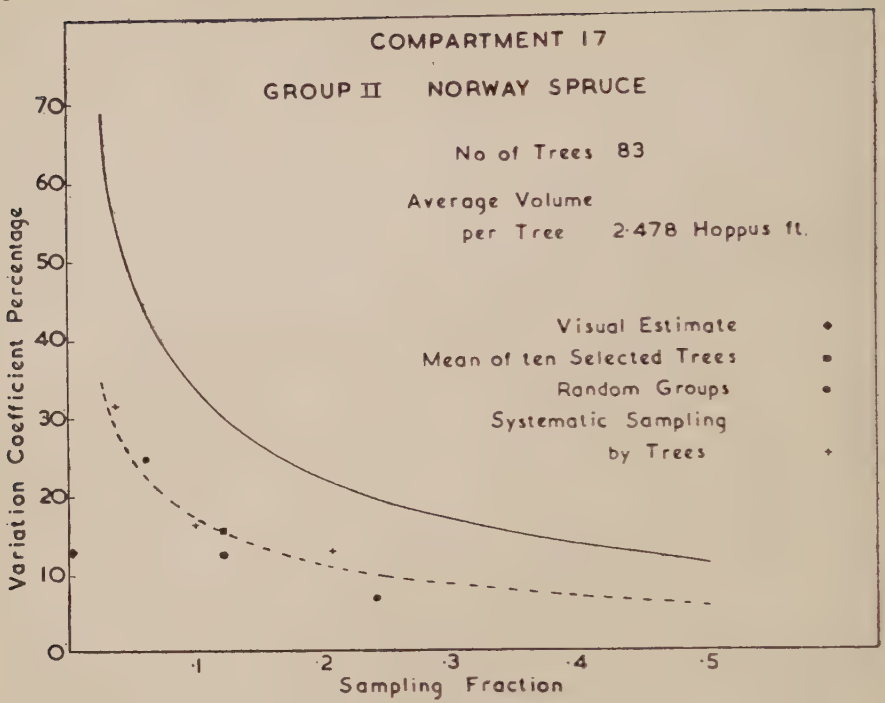


Fig. 7. Kinellar

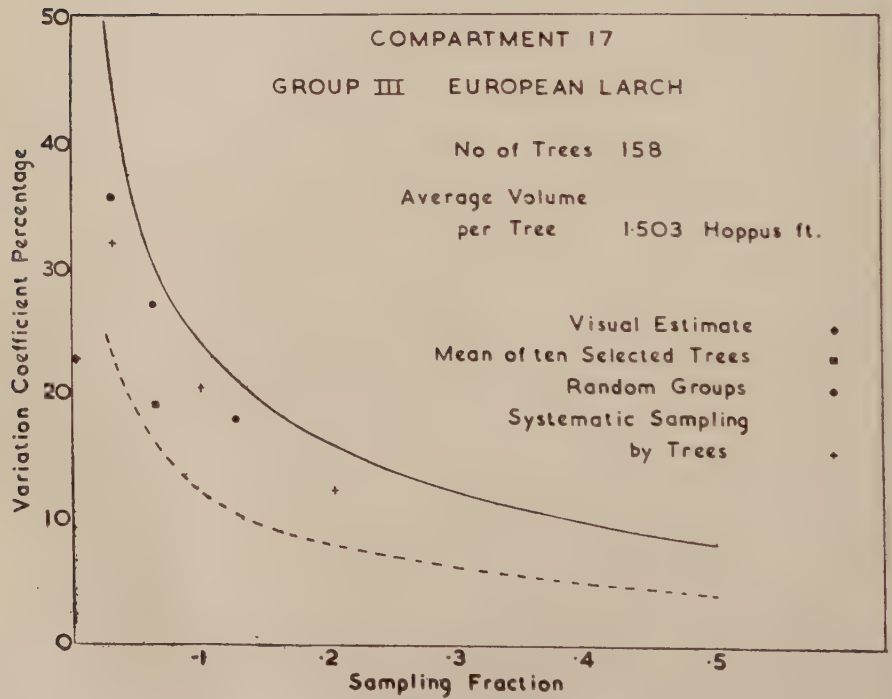


Fig. 8. Kinellar

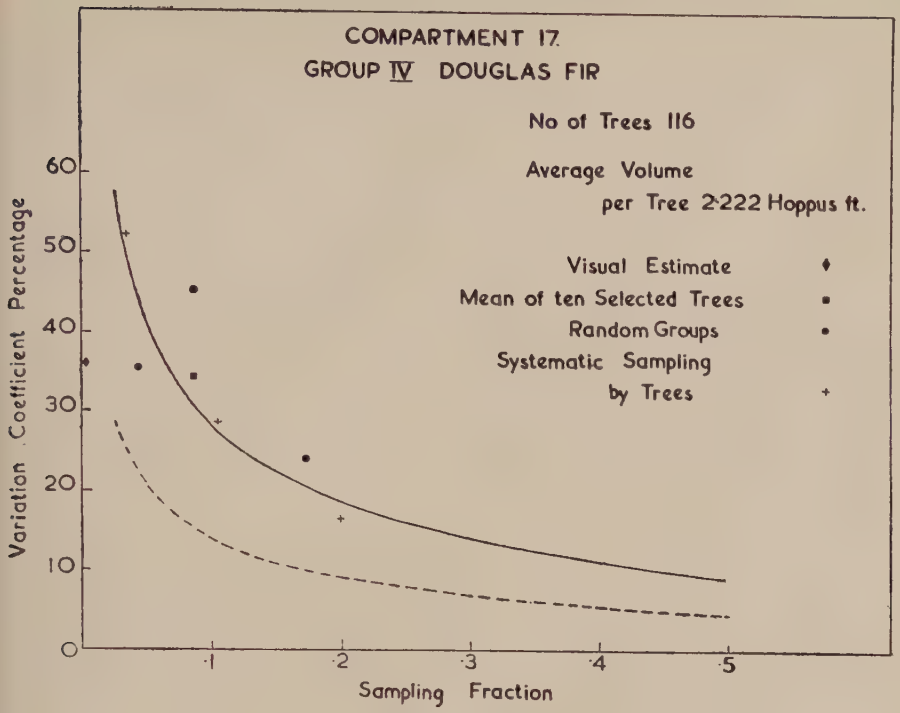


FIG. 9. Kinellar

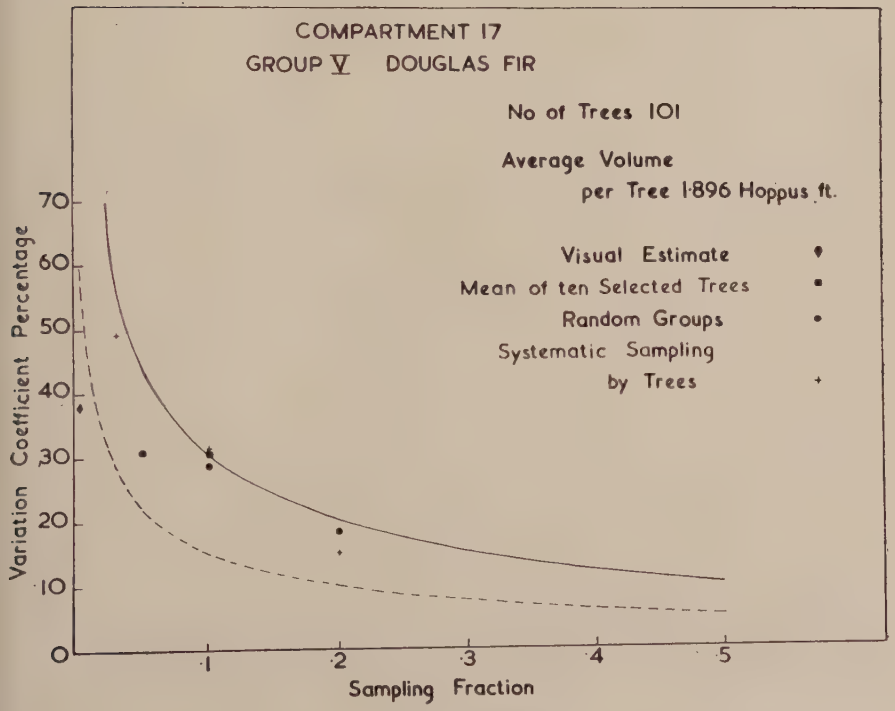


FIG. 10. Kinellar

THE EFFECT OF pH AND FORM OF NITROGEN ON THE GROWTH OF SITKA SPRUCE SEEDLINGS

By L. LEYTON

(Department of Forestry, University of Oxford)

SUMMARY.

The effect of pH and form of nitrogen (NH_4 and NO_3) on the growth of Sitka spruce seedlings (*Picea sitchensis*, Carr.) has been investigated in nutrient culture solutions over the range pH 3–7. In both nitrogen series the reaction for optimum growth of both shoot and root appears to lie between pH 4 and 5. Above and below this range there is a progressive fall in dry-weight production accompanied by increasingly abnormal root development. The form of nitrogen supplied appeared to have little effect on total growth at equivalent reactions, but from the root/shoot ratios it seems that nitrate nitrogen stimulates a greater relative root production than does ammonia nitrogen.

INTRODUCTION.

IT has been recognized for a long time that the pH of the soil is one of the important factors determining plant growth. Experience in the growth of coniferous seedlings in nurseries emphasizes the importance of maintaining a suitable pH in the seed-bed. Under field conditions, however (including seed-beds), it is fundamentally impossible to distinguish between the effects of pH *per se* and the effects of other soil factors which are influenced by the pH of the soil. Thus any soil treatment which involves an appreciable change in pH will invariably affect the activities of soil micro-organisms (e.g. nitrification processes) and the availability of mineral nutrients (e.g. Fe and Mn) so that the interpretation of growth responses merely in terms of soil acidity is in many cases unwarranted or even misleading. Further difficulties are involved in studies on soil reaction in that, despite the existence of well-established methods for measuring soil pH (indicators, quinhydrone and glass electrodes), the different methods do not always give the same results even on the same soil. Nor is there a really standard technique by which different investigators can compare their findings with real confidence. Using the glass electrode with a typical nursery soil it has been possible to obtain so-called pH values ranging over more than 1 unit merely by varying the ratio of soil : water. It is most likely that the range would be extended still further by including pH measurements made by other methods. By adopting the identical procedures in each case it is, of course, possible to make useful comparisons of different soils, but it is evident that the pH values obtained are to a great extent purely arbitrary and we are still in doubt as to their precise significance, particularly in their effect on seedling growth.

With this in mind it was realized that the only way in which the pH effect could be isolated from other interrelated factors was to grow seedlings in nutrient culture solutions which could be varied as to pH but kept constant as far as other important growth factors are concerned. At the same time the use of culture solutions would avoid any difficulties in the precise evaluation and interpretation

of the pH measurements made on these solutions. A somewhat similar technique has been used by Arnon (1) and Arnon and Johnson (2) for a number of different crop plants. Shibamoto *et al.* (6) have recently employed the same technique with tree seedlings.

The adoption of the culture solution technique also allows the investigation of another factor which under natural conditions is invariably associated with soil acidity, namely the form of nitrogen available to the plant. Although the relative merits of the ammonium (NH_4) and nitrate (NO_3) forms of nitrogen are by no means established, there appears to be a general impression, at least as far as crop plants are concerned, that the nitrate form is superior—particularly since this form is associated with the more fertile soils. In the case of coniferous species, however, the majority are usually grown on acid soils where conditions are usually unfavourable for the nitrifying bacteria and where often little or no nitrification occurs so that nitrogen is available mainly in the form of the ammonium (NH_4) ion. Since quite successful stands can be grown under such conditions, it would appear that for many coniferous species, nitrogen in the form of the ammonium ion is sufficient. Nevertheless, it has often been observed, even with coniferous species, that soil treatments leading to increased nitrification generally lead to improved tree growth. It is very difficult in the field to deduce from such observations whether improved growth is due to a change in the form of the available nitrogen or whether other soil factors are partly or wholly responsible. Again it is possible by adopting a suitable culture technique to compare the growth of seedlings supplied either with ammonium or nitrate nitrogen, all other important growth factors remaining constant.

EXPERIMENTAL.

It must be emphasized at the beginning that, in practice, it is impossible to vary the pH or the form of nitrogen in a culture solution so that *all* other factors remain constant. It is, however, possible to obtain a series of solutions which vary in pH and form of nitrogen and which are constant as far as the more important nutrient elements are concerned (phosphorus, potassium, calcium, and magnesium) but which vary with respect to their sulphur and sodium contents. This has been done by Arnon (1) and it would appear that the variation in sulphur or sodium does not invalidate the results to any serious extent. The solutions used were very much the same as those quoted by Arnon and were of the following composition:

Ammonium series (g./litre)		*Nitrate series (g./litre)*		*Composition (parts per million)*	
$MgSO_4\ 7H_2O$	0·74	$MgSO_4\ 7H_2O$	0·74	N	56
K_2SO_4	0·26	K_2SO_4	0·17	P	124
$Ca(H_2PO_4)_2H_2O$	0·50	$Ca(H_2PO_4)_2H_2O$	0·38	K	117
$CaSO_4$	0·20	KH_2PO_4	0·14	Ca	140
$(NH_4)_2SO_4$	0·26	$Ca(NO_3)_2\ 4H_2O$	0·47	Mg	73
Fe citrate	0·02	Fe citrate	0·02		

To each litre of solution was added 1 c.c. of a micronutrient solution of the following composition:

$CuSO_4\ 5H_2O$	0·055	g./litre.
$ZnSO_4$	0·035	
H_3BO_3	0·61	
$MnCl_2\ 4H_2O$	0·39	

By the addition of the appropriate amounts of dilute sodium hydroxide or sulphuric acid the solutions could then be adjusted to the desired pH. For each form of nitrogen, five cultures were set up with initial pH values of 3, 4, 5, 6, and 7. The composition of the solutions was such that no precipitation occurred even in the most alkaline stages.

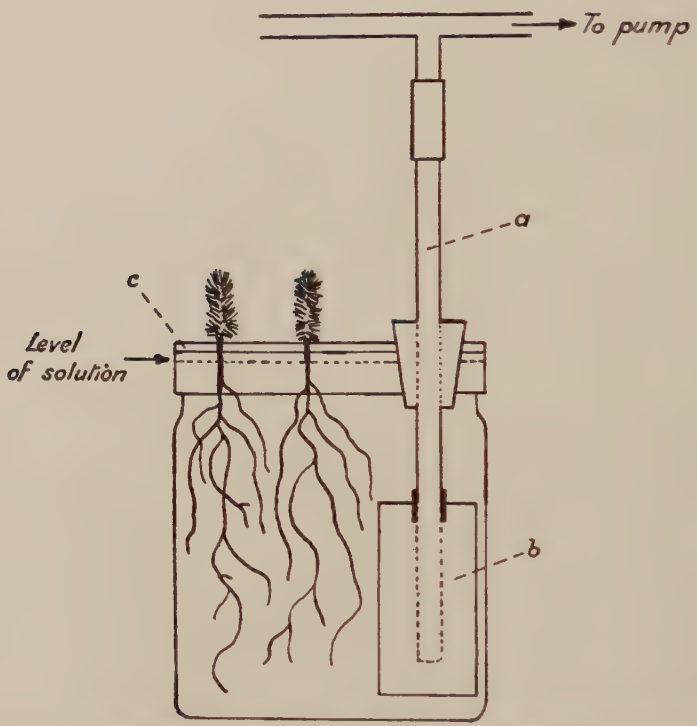


Fig. 1. Culture vessel for spruce seedlings. *a* aerating tube, *b* carborundum block aerator, *c* wax impregnated mesh.

On 14th June seeds of Sitka spruce were germinated between layers of cheesecloth kept saturated with water. When the radicles were about ½ inch long they were transferred to the culture vessels (cf. Fig. 1). These consisted of ordinary glass jars, of about 400 c.c. capacity and painted black on the outside to exclude light from the solution. The seedlings were supported above the level of the solution on curtain netting impregnated with paraffin wax so that only the radicles were submerged. Aeration was obtained by means of blocks of crude

porous carborundum (2 in. × 1 in. × 1 in.) into which were inserted glass tubes connected by a common air supply tube to a small electric rotary pump. By means of a suitable timing device, the pump was arranged automatically to aerate the solutions for ½ hour every 5 hours. This aerating mechanism gave very little trouble and proved most efficient.

Approximately 20 seedlings were grown in each vessel. During the first week or so seedlings which failed to develop or which showed pathological symptoms were replaced by new ones, but after this abnormal seedlings were removed and not replaced. The number of seedlings which survived throughout the whole growing period (more than 4 months) varied a great deal. At the extreme pH values, the mortality was rather high and only about 25 per cent. survived, whereas at intermediate pH values almost 100 per cent. survival was obtained.

Until the cotyledons expanded, the culture solutions were maintained at half strength; after this full-strength solutions were supplied. These solutions were replaced approximately every fortnight, but despite this it was found impossible to maintain the pH at the initial value. They were, of course, very poorly buffered and, as was expected, the ammonia nitrogen solutions tended to become more acid whilst the nitrate nitrogen solutions tended to become more alkaline. Periodical checks, however, showed that in no case did the pH change by more than one unit. Occasional analyses of the ammonium solutions showed also that no appreciable nitrification had occurred during the period between replacements.

On 10th November the seedlings were removed from the culture vessels, separated into shoot and root, dried in an oven at 105°, and weighed individually. Average dry weights and root/shoot ratios per culture are given in the following table:

Average Dry Weights (to nearest mg.) and Root/Shoot Ratio

	NH_4-N *Series*					NO_3-N *Series*				
Initial pH	*No. of seedlings*	*Root*	*Shoot*	*Total*	*R/S*	*No. of seedlings*	*Root*	*Shoot*	*Total*	*R/S*
7	12	11	19	30	0·54	17	9	13	22	0·69
6	18	16	28	44	0·58	16	13	18	31	0·73
5	18	15	34	49	0·48	17	16	27	43	0·61
4	11	13	30	43	0·44	14	21	34	55	0·62
3	6	10	20	30	0·47	10	10	15	25	0·66

DISCUSSION.

Effect of pH

There is little doubt that the reaction of the culture solution has exerted a marked influence on the growth of the seedlings, in both ammonia and nitrate nitrogen series (cf. Figs. 2, 3, and 4). In the ammonium series, maximum dry weight production occurs in the solution with an initial pH of 5, whereas in the nitrate series the maximum occurs at pH 4. The apparent anomaly between these findings must be explained by the displacement in pH during the period between

replacement of nutrient solutions. If we assume that the initial pH was displaced upwards in the nitrate series and downwards in the ammonium series, then both series show maximum dry-weight production over the same pH range, i.e. 4 to 5 (cf. graph, Fig. 5).

The variation in dry-weight production with pH is similar for both root and shoot. At the extreme pH values the roots show marked abnormalities, particularly in the ammonia-nitrogen series with an initial pH 3 and in the nitrate-

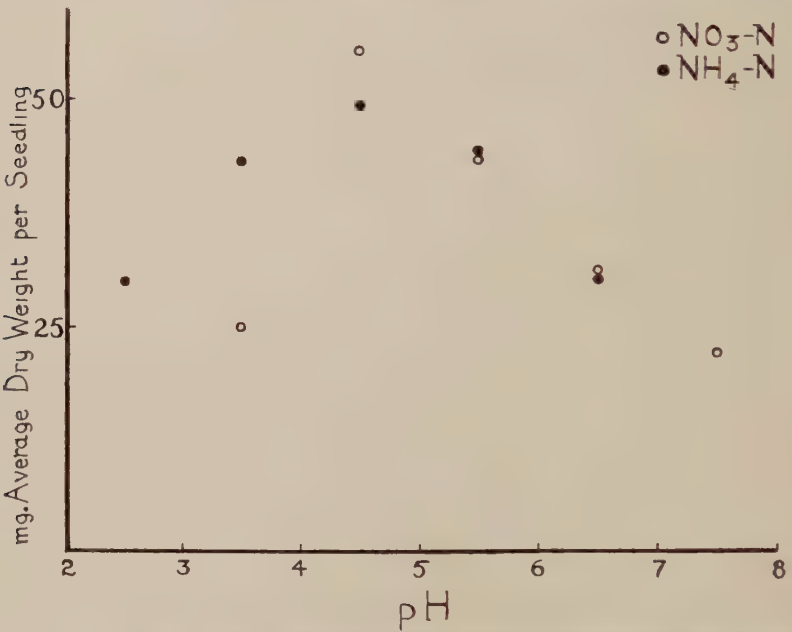


Fig. 5. Relationship between average dry weight production per seedling and average pH range of culture solutions.

nitrogen series with an initial pH 7. Figs. 6 and 7 illustrate the typical appearance of the root systems at the different reactions. In the most acid solutions the roots were of an unhealthy brown coloration, typically stunted and bunched with a rather thickened main root system and small stubby rootlets. At the intermediate reactions the root systems were much lighter in colour and more extensive with much finer main roots and longer rootlets. In the most alkaline solutions (e.g. nitrate series, initial pH 7) the production of rootlets was almost entirely suppressed. In colour they resembled the roots in acid solutions, but were much smaller in diameter.

At all except the most alkaline reactions the shoots appeared to possess the normal green coloration. At pH 7 (and particularly in the nitrate series) there were definite signs of chlorosis. It is possible that in spite of the presence of sufficient Fe in the culture solutions, the high pH renders the Fe unavailable, but in the absence of further investigations the nature of the chlorosis cannot be established.

The relative growth of root and shoot (root/shoot ratio) does not appear to show any consistent change with pH in either series, though there is a tendency for the higher ratios to occur in the more alkaline solutions.

Effect of form of nitrogen

From the graph (Fig. 5) it will be observed that there is little difference between the effect of ammonium and nitrate nitrogen on the dry-weight production of the whole seedlings. At pH 3–4 the nitrate series produced what appears

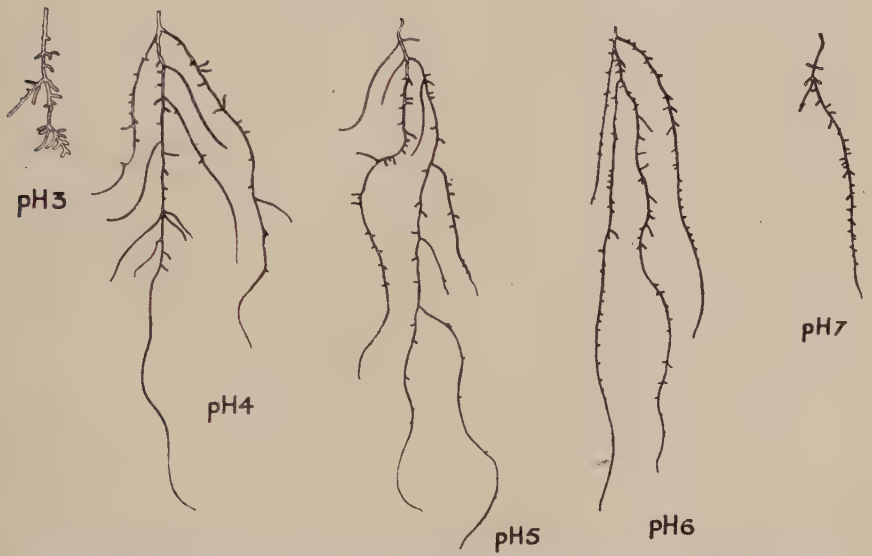


FIG. 6. NITRATE series. Typical root system of Sitka spruce seedlings grown in solutions with different initial pH values.

to be an abnormally low yield, whilst at the optimum pH (4–5) this series shows a rather higher average yield. At the higher reactions, however, there is a remarkably good agreement between the two series.

The most outstanding difference between the effects of these forms of nitrogen occurs in the root/shoot ratios. It would appear that relatively greater root production occurs in the seedlings provided with nitrate nitrogen. In actual appearance, however, there is little difference between the root systems at equivalent pH values (if allowance is made for the displacement of pH during growth) (cf. Figs. 6 and 7). On the whole, survival appears to be somewhat better in the nitrate series.

CONCLUSIONS.

By adopting the nutrient solution technique it has proved possible to demonstrate a marked effect of pH on the growth (dry weight production) of Sitka spruce seedlings.

Although in practice it is impossible to keep all other factors constant, it is believed that the differences in growth are due to the differences in pH *per se* and not to differences in the sulphur or sodium supply. It is interesting to note that when allowances are made for the displacement in pH (as a result of unequal cation and anion absorption) the reaction associated with optimum growth is in agreement with that often found in nursery practice. At the extreme pH values

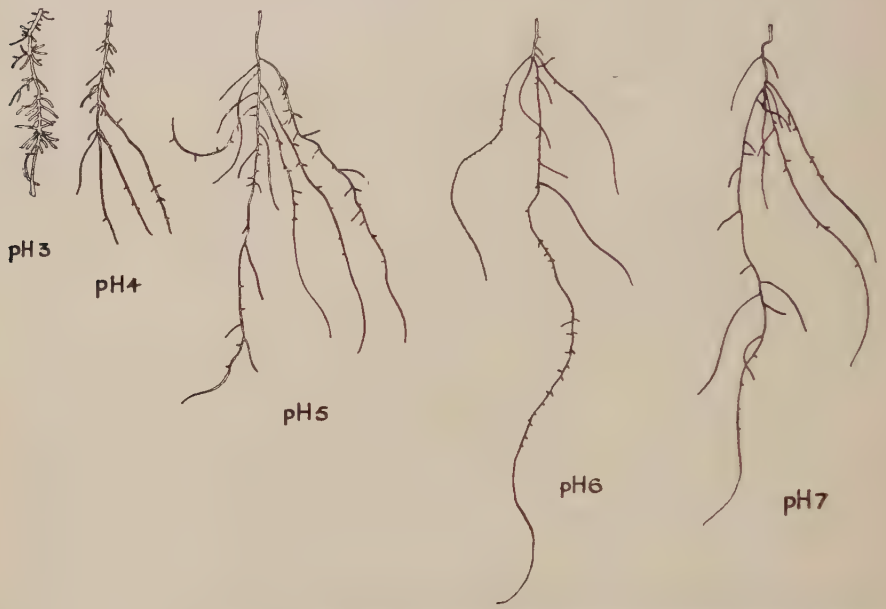


FIG. 7. AMMONIUM series. Typical root systems of Sitka spruce seedlings grown in solutions with different initial pH values.

the roots show characteristic abnormalities and again there is a large measure of agreement with observations made in the field. Under normal conditions, of course, it is unlikely that the more acid reactions (as in the most acid ammonium solutions) will ever be encountered, particularly in the nursery, except perhaps in some heathland nurseries, but many cases have been reported where pH values of 7 and over are not unusual (e.g. old agricultural land turned over to nursery practice). The characteristic chlorosis of Sitka spruce observed in such cases is paralleled in the cultures, particularly in the nitrate series.

Little difference has been established between the different forms of nitrogen supplied to the seedlings in respect of dry-weight production. For coniferous seedlings, however, this may not be as surprising as it might seem since under field conditions the nature of the soil under a coniferous crop in many cases would hardly support an active nitrifying flora. Nitrate nitrogen, however, does appear to stimulate a better relative root production and in this respect it would offer advantages to seedlings when transplanted, though at the same time, of course, there is a greater danger of root injury during lifting.

Nevertheless, the findings in culture solution are not quite in accord with observations made on the behaviour of Sitka spruce in the field. According to Taylor (7), who investigated natural regeneration in the forests of Alaska, Sitka spruce regenerates most abundantly where active nitrification is taking place and only scarcely or not at all on non-nitrifying soils. Other investigators (e.g. Hesselman (3)) have also stressed the relative superiority of nitrifying soils for the regeneration and growth of spruce seedlings. Again, however, we are dealing here with natural soils in which a whole complex of interrelated factors is involved so that it is virtually impossible to dissociate one factor from another. For example, it is well known that soils supporting an active nitrifying flora are invariably superior in physical properties to soils in which no nitrification takes place. The fact that regeneration of spruce is associated with the presence of nitrate nitrogen in the soil does not necessarily establish a causal connexion and it is very likely that other soil factors are involved. In addition, the occurrence of mycorrhizae may well alter the relationship between seedling development and the nature of the medium surrounding the roots, so that some caution is necessary in interpreting the results of culture experiments in terms of behaviour in the field.

A factor which is of great importance in culture work is, of course, the composition of the culture solutions. Mitchell (4) has shown that for coniferous seedlings optimum growth is associated with optimum concentrations and balance of the various nutrients supplied. The optimum concentrations quoted by Mitchell for pine differ appreciably from the concentrations used in the present work, but restrictions imposed by the nature of the investigation (e.g. wide pH range) limited the choice of suitable culture solutions. (It is interesting to note that Olsen (5) recommends much higher concentrations of nutrients for spruces than for pines.) The possibility that a different balance between the various nutrients might affect the results must always be borne in mind, but in the absence of more intensive work in this field, this possibility cannot be confirmed. Nevertheless, even with the present composition of the culture solutions quite healthy average-sized seedlings were obtained at the intermediate pH values. The fortnightly replacements of the nutrient solutions, whilst appearing adequate for the nutrition of the seedlings, proved too infrequent for the maintenance of the pH at its initial level. Probably the most satisfactory solution to this would be a flowing culture technique, but its maintenance over a period of some months would present rather overwhelming practical difficulties with ordinary laboratory facilities.

The findings established in this work are sufficiently interesting to warrant a more intensive investigation into the physiology of the pH effect, in particular the effect on rate of absorption of the various mineral nutrients. The dried plant material has been stored and it is hoped that future analyses of the tissues will provide some information on this point.

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FIG. 2. Appearance of cultures towards the end of the experiment. Figures refer to initial pH values.

PLATE III

PLATE IV

NITRATE NITROGEN

FIG. 3. Appearance of typical Sitka spruce seedlings from cultures with different initial pH values

PLATE V

AMMONIA NITROGEN

FIG. 4. Appearance of typical Sitka spruce seedlings from cultures with different initial pH values

CONTROL OF *FOMES ANNOSUS* FR.

By J. RISHBETH

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SUMMARY.

The life-history is outlined and some existing control methods reviewed. New methods are suggested and the experiments which tested some of them are described. Evidence is given that infection can greatly be reduced by covering conifer stumps, *immediately after felling the trees*, with a mixture of tar and creosote or with a suitable paint. Some biological control of stump infection is exercised by the purely saprophytic fungus *Peniophora gigantea*, but it is not possible at present to suggest a cheap, practical method for facilitating this control. The practical value of the various methods is discussed and the importance of instituting some form of control is emphasized.

INTRODUCTION.

FOMES annosus Fr. is an important cause of disease in coniferous forests and plantations. Although the extent and nature of the damage it causes have long been recognized, many aspects of its epidemiology have remained obscure and the relation between butt rot and tree killing has been imperfectly understood. It is hardly surprising, therefore, that control measures so far devised have not been conspicuously successful. Recent work on *F. annosus* in East Anglia [Rishbeth, (13) to (17)] has provided further information about the biology of the fungus and has indicated at least one simple and effective control method in certain circumstances.

OUTLINE OF THE LIFE-HISTORY.

To discuss adequately control of a parasite, an understanding of its life-history and ecological status is essential. *Fomes annosus* inhabits stumps and roots and does not grow freely in soil: it is virtually absent from sites without trees and stumps and from young plantations established on them. The parasite first appears in such plantations when trees are cut down: this occurs most frequently after thinning but also after rack-cutting and felling of adjacent trees. It has been clearly shown that *F. annosus* enters freshly cut stumps through the exposed surface, which is commonly infected by air-borne spores. The sporophores which liberate these spores are mostly produced on stumps and dead trees when the air is sufficiently humid, but may also be formed on roots under litter or in burrows. Where the disease is already present in a plantation, stumps may be infected not only in this manner but also from roots already containing the parasite at the time of felling; observations made in one plantation suggested that, of stumps produced by the third thinning, about 10 per cent. may become infected in this way. From the original region of infection, *F. annosus* grows into the body of the stump and often becomes dominant there. It then passes from stump roots to

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living roots touching them and under some conditions spreads by further root contact to adjacent trees from those first infected. Progress of infection in living roots is influenced by many factors: in certain circumstances it leads to death of the tree and in others to butt rot. Trees seldom show crown symptoms until the roots are extensively infected. Resistance of trees to killing by the parasite increases with age and is influenced by various site factors. Trees are unlikely to be infected through roots killed by adverse physical conditions since *F. annosus* can compete with saprophytic fungi in such roots only to a limited extent.

REVIEW OF SOME EXISTING CONTROL METHODS.

In a paper on butt rot, Peace (12) has reviewed various methods for controlling *F. annosus*. In the following discussion, further consideration has been given to some of these methods, and others not mentioned in that paper are also discussed. The control methods suggested are of two main types: some aim to limit the severity of an attack once it has arisen and others seek in advance, either by soil treatment or by choice of crop, to create conditions under which severe attacks are unlikely to develop.

Of methods in the first category, trenching was suggested by Hartig (5) over 50 years ago. This has proved moderately satisfactory with some diseases but not with others [Garrett (4)]. The delayed appearance of crown symptoms in trees attacked by *F. annosus*, particularly in the case of butt rot, renders correct siting of a trench difficult if not impossible. The fact that sources of infection tend to be widely scattered reduces the value of this form of control which at best is only palliative. In East Anglia earlier attempts to check the advance of *F. annosus* in pine plantations by trenching were found to have failed. The method cannot therefore be recommended.

Jørgensen, Lund, and Treschow (7) advise judicious thinning, presumably to reduce competition between trees and hence to increase their resistance to disease. It is doubtful whether on balance much would be gained since thinning produces more potential sources of infection. Furthermore, if slightly affected trees are felled, *F. annosus* invades their root systems more rapidly than if they are left standing.

Other methods aim to reduce the incidence of disease by soil treatment. De Koning (3) advocates removal of surface litter and humus in strips before replanting woodland sites, presumably on the assumption that *F. annosus* spreads from tree to tree through this layer. This assumption is widespread [Björkman, (2)] and exists in spite of the fact that the fungus will not grow on unsterilized humus. The presence of small *F. annosus* sporophores in the litter of some affected plantations has very probably contributed to the belief, but such sporophores are invariably attached to small rotted roots. *F. annosus* in fact spreads from tree to tree along roots and thus control by removal of litter or humus is ineffective.

Jørgensen and Treschow (8) have shown that growth of *F. annosus* on laboratory culture media and sterilized soil declines rapidly above pH 6·0 and they have therefore attempted to control the parasite by increasing soil pH through addition of lime or phosphate. The effect of pH on the growth of a fungus on such media,

however, is not a reliable guide to its behaviour in the field, and in fact *F. annosus* spreads more freely from root to root in alkaline than in acid soils because the root surface microflora in the latter soils is antagonistic to it [Rishbeth (14)]. The treatment suggested by Jørgensen and Treschow is therefore likely to have exactly the opposite effect to that intended.

Huet (6) suggests that, when pines are to be replanted on affected areas, the soil should be left untouched for 4–5 years. On one East Anglian site a very serious outbreak followed replanting 7 years after the previous crop had been felled; in another site, some disease developed when felling preceded replanting by over 20 years. Any control measure involving natural replacement of the parasite by other fungi in large stumps should allow an interval after felling of the order of 30 years and would therefore be impracticable.

Tree selection is another possible means of reducing incidence of disease. Sylvén (18) recommends collection of seed from immune trees in the midst of heavily infected spruce stands and thus raising disease-resistant strains. Since attacks of *F. annosus* develop from definite centres of infection, survival is far more often associated with disease escape than with immunity. Isolated surviving trees present inside disease gaps often have most of the main roots extending in a direction away from the gap, so here again survival is not necessarily caused by immunity. Although this approach to the problem is feasible, caution must clearly be exercised in selection.

Care in choice of species is mentioned by Anderson (1) and is thought by Peace (12) to be the only practicable means of controlling butt rot caused by *F. annosus*. The importance of selecting the right species for a given site cannot be overestimated: a species well suited to its environment is likely to resist parasitic attack more effectively than one which is not. It is unfortunately true, however, that outbreaks of *F. annosus* occur in some areas where a correct choice of species appears to have been made. This is the case in East Anglia where pines (*Pinus sylvestris* L. and *P. nigra* var. *calabrica* Schneid.) have been extensively planted: severe attacks have occurred in sites favouring heavy root infection. As Peace points out, a correct choice of species may to some extent mitigate the disease but will not prevent it.

Jørgensen and Treschow (8) note that, in Denmark, Norway spruce is often infected by *F. annosus* through a perpendicular tap root and therefore, to prevent formation of such roots, they suggest planting trees with the root system spread out flat. Løfting (10), working in the same country with Sitka spruce, states on the other hand that attack by *F. annosus* is most likely to occur when the roots lie high. In East Anglian pine plantations initial infections are most frequent on lateral roots lying at some 15–30 cm. depth. The suggested control method could thus be useful only in certain circumstances.

OTHER POSSIBLE CONTROL METHODS.

Since with attacks of *F. annosus* the initial sources of infection are stumps, from which the parasite spreads from root to root, other approaches to the problem of control can be made.

(*a*) *Reduction of root contacts*

The number of root contacts could be reduced by wider spacing which might also increase resistance of trees to the disease. However, any marked reduction in severity of attack would probably require a doubling of the planting distance, which is impracticable. More feasible is the establishment of mixed conifer and hardwood crops in which root contacts between susceptible conifers are reduced. This solution has often been suggested before, but is only practicable in certain circumstances.

(*b*) *Restriction of thinning*

Conifers tend to become more resistant to killing by *F. annosus* with age and hence the later they are subjected to root infection the less severe the outbreak will be. In the absence of other effective means of control, delay of operations such as thinning and rack-cutting would thus be beneficial. Incidence of butt rot, as opposed to killing, is, however, unlikely to be much reduced by this means.

(*c*) *Stump extraction*

Of other methods designed to reduce potential sources of root disease, the most drastic is complete removal of stumps. This was tried on a small scale in East Anglia, once after rack-cutting and once after thinning. In the first experiment the trees were 11 years old and results appeared satisfactory: no source of infection remained. In an adjacent site 2 years later, typical root infections were found near comparable rack stumps which had not been removed. In the second experiment the trees were 20 years old and considerable difficulty was experienced in extracting stumps. Extraction of even larger stumps in a clear-felled site would be a formidable task. Although this method should ensure complete protection, difficulty and cost render it impracticable except perhaps after rack-cutting in young plantations.

(*d*) *'Passive' stump protection*

Another possible line of approach is to leave stumps *in situ* and to try and exclude *F. annosus* from them. Since airborne spores of *F. annosus* very frequently infect stumps, the effect of treating the cut surface in various ways after felling was clearly worth investigating. Four protectants were tested, viz. creosote, a mixture of $\frac{2}{3}$ tar and $\frac{1}{3}$ creosote, 'maintenance paint', and 'titanium paint'. The maintenance paint was an ordinary quality oil gloss paint in general use by the Forestry Commission, the specification being as follows: 'lithopone and zinc oxide pigment in a medium of linseed oil, turpentine substitute, and terebine driers, with a small amount of phenol as a preservative.' The titanium paint was the best quality paint obtainable at the time, the specification being as follows: 'pigmented with 75% standard titanium white and 25% zinc oxide, the medium being genuine heat-treated linseed oil thinned with white spirit'. In the first experiment, carried out in 1947, a plantation of 21-year-old pines on former arable, not previously thinned, was divided into plots one chain wide. Immediately after thinning stump surfaces were creosoted, painted with 'maintenance paint' or

covered with 4–5 cm. of soil; in other plots they remained exposed as in normal practice. These plots, each containing stumps treated in one way, were repeated along the length of the plantation. A year after felling samples were taken and the proportion of stumps containing *F. annosus* calculated by the method described elsewhere [Rishbeth (15)]. The results are given in Table I.

TABLE I. *The Percentage of Pine Stumps infected by* Fomes annosus *following Various Treatments of the Cut Surface carried out immediately after Felling*

Treatment	*No. of plots*	*No. of stumps examined*	*Mean percentage stumps with* Fomes annosus
None	4	228	36
Creosoted	4	213	4
Painted	4	211	4
Covered with soil	3	112	51

The incidence of *F. annosus* was much lower in creosoted or painted stumps than in those left exposed. The heavy infection in stumps covered by soil was unexpected. Further experiments showed that *F. annosus* spores alighting on soil are washed down and remain viable for a period. If soil containing such viable spores is used to cover freshly cut stumps, the latter often become infected. Covering with soil is therefore useless as a control method.

In view of the encouraging results obtained with creosote and paint, further experiments were set up in similar plantations during 1949. Since stump surfaces tend to crack while drying out, it was thought desirable to try a more plastic covering. A mixture of $\frac{2}{3}$ tar and $\frac{1}{3}$ creosote, suggested by the Director, Forest Products Research, Princes Risborough, was accordingly tested in some plots. Stumps in other plots were painted with 'maintenance paint' and those in the remainder left exposed, as before. Results of one such experiment, in which successive blocks of plots were thinned at fortnightly intervals, are given in Table II: stump infection did not vary appreciably from block to block in this instance.

TABLE II. *Further Results obtained by treating the Cut Surface of Pine Stumps immediately after Felling*

Treatment	*No. of stumps examined*	*No. with* Fomes annosus	*Percentage with* Fomes annosus
None	40	6	15
Painted	40	0	0
Tar/creosoted	40	1	2·5

Although the incidence of natural infection with *F. annosus* was lower than in the previous experiment, treatment with tar/creosote and paint clearly gave good control.

In a third experiment three blocks of plots were thinned at monthly intervals, but the first two blocks were useless because the incidence of stump infection by *F. annosus* in untreated controls was very low. In the third block *F. annosus* was present in stumps as follows: untreated control, 6/20 (30 per cent.); painted with 'titanium paint', 0/15 (0 per cent.); tar/creosoted 0/15 (0 per cent.). The treatments were again effective. A further small experiment testing creosote alone and a mixture of copper sulphate and sodium dichromate (each a 2·5 per cent. solution) failed because untreated stumps were not infected with *F. annosus*.

Results of experiments so far described are summarized in Table III: plots having a very low incidence of stump infection with *F. annosus* in untreated controls are omitted.

TABLE III. *Summary of Results obtained by treating Stump Surfaces in Various Ways directly after Felling*

Treatment	*No. of sites*	*No. of plots*	*Mean percentage stumps with* Fomes annosus	
			Untreated plots	*Treated plots*
Painted . . .	3	9	27	2
Creosoted. . .	1	4	38	6
Tar/creosoted . .	2	5	18	2

Treatment of stump surfaces with paint, creosote, or tar/creosote thus gives an average of approximately 90 per cent. protection against infection by *F. annosus*; tar/creosote gives the most plastic covering and is therefore preferable. In these experiments the cost of application and materials varied from £1. 6*s*. 2*d*. to £2. 2*s*. 7*d*. per acre with the tar/creosote treatment and from £1. 6*s*. to £1. 18*s*. 6*d*. with painting: in each case the average was about £1. 16*s*. per acre. Variations are, of course, due to the number of stumps treated per acre. The cost of these control methods should thus be offset by the value of timber saved in the current crop alone. The chief disadvantage lies in the fact that these methods do not prevent *F. annosus* from growing into stumps from roots already infected at the time of felling; but in most plantations the proportion of such stumps is probably small.

(*e*) '*Active*' *stump protection*

Some root parasites readily colonize stumps in which food reserves are abundant but cannot colonize stumps in which such reserves are depleted, owing to competition from saprophytic fungi. This principle underlies methods of biological control already suggested for some root parasites. Thus Leach (9) recommends ringing of jungle trees before felling in order to discourage growth of *Armillaria mellea* into the stumps from dormant root lesions. Similarly Napper (11) found that poisoning of rubber stumps with sodium arsenite resulted in rapid killing and invasion by saprophytes rather than by the parasite *Fomes lignosus*. With conifer plantations, however, large-scale ringing of trees would almost certainly

lead to severe damage from bark-beetles. Conifer stumps would doubtless be killed quickly by poisoning, but this operation is more expensive than painting or creosoting and might prove dangerous in plantations easily accessible to the public. Further, it is doubtful whether fungal competition in poisoned stumps would always be sufficiently intense to exclude *F. annosus*, for saprophytes capable of colonizing stumps are apparently scarce in some soils.

However, another method of biological control is possible. *Peniophora gigantea* (Fr.) Massee, an actively wood-rotting fungus frequent in conifer plantations, has been shown to replace *F. annosus* in lengths of pine roots in the laboratory and in small pine stumps (about 8 cm. diameter) under natural conditions [Rishbeth (14) and (15)]. It was thought, therefore, that if pine stumps could be inoculated soon after felling with *P. gigantea*, this fungus might become sufficiently established to prevent colonization by air-borne spores of *F. annosus*. Further, such treatment might check growth of *F. annosus* in stumps whose roots were partially infected at the time of felling. Small-scale experiments to test these possibilities were set up in East Anglia in 1949.

In one experiment small wedges (4 cm. long and 2 cm. wide) cut from pine stumps naturally infected with *Peniophora gigantea* were used as inocula. (In East Anglia, stumps containing this fungus can be readily identified throughout most of the year by the grey gelatinous fructification.) A small split was made in the centre of the stump surface with a cold chisel and a wedge then hammered into position. Since small patches of disease caused by *F. annosus* were already present at this site, wedge inoculation was in the first instance confined to stumps well removed from these patches. Stumps were inoculated 3–4 days after felling and were sampled, as before, about a year later. Results are given in Table IV.

TABLE IV. *Results obtained by inoculating the Cut Surface of Pine Stumps with* Peniophora gigantea *soon after Felling*

Treatment	*Total No. of stumps*	*No. with* Fomes annosus	*Percentage with* Fomes annosus
None	40	6	15
P. gigantea wedge inserted	40	2	5

Although the incidence of natural infection in the untreated control was not as high as could be desired for the purpose of the experiment, the figures suggest that wedge inoculation with *P. gigantea* reduces natural infection of stumps by air-borne spores of *F. annosus*. Failure of this method to give complete protection is probably due in part to the observed tendency for fungi colonizing stumps to grow downwards faster than laterally. Thus mycelium produced from spores of *F. annosus* alighting near the stump periphery soon after felling might well escape competition from *P. gigantea* for some time.

Also at this site, five stumps having one or more lateral roots already infected by *F. annosus* were inoculated with *P. gigantea* wedges at the same time as the others. A year later two of these five stumps were found to be infected with

F. annosus almost at the surface. Since the percentage infection (40) was higher than that in wedge-inoculated stumps in the main experiment (5), it appears that wedge inoculation had failed to prevent growth of *F. annosus* upwards into the stumps.

A second experiment testing wedge inoculation with *P. gigantea* failed because the incidence of natural infection by *F. annosus* in untreated stumps was far too low to assess effectiveness of the treatment. In a third experiment, two preventive treatments were given to stumps cut the previous day: with some, a *P. gigantea* wedge was inserted centrally as before, and, with others, a suspension of *P. gigantea* spores was sprayed over the whole surface by an atomizer. This suspension was prepared by washing an agar culture of *P. gigantea* with sterile water, which removed vast numbers of truncate spores or oidia. The treated stumps, along with others receiving no treatment, comprised three series, in each of which half the stumps were further sprayed with a spore suspension of *F. annosus*, to ensure that the preventive treatments would be effectively tested, and half were left to natural infection by *F. annosus*. A year later, the following results (Table V) were obtained from stumps deliberately inoculated with *F. annosus*: the fungus was absent from those not so inoculated.

TABLE V. *Results obtained from Pine Stumps inoculated with* Peniophora gigantea *and further inoculated with* Fomes annosus *soon after Felling*

Treatment	*Total No. of stumps*	*No. with* Fomes annosus	*Percentage with* Fomes annosus
F. annosus spores only . . .	18	14	78
F. annosus spores+*P. gigantea* wedge .	17	8	47
F. annosus spores+*P. gigantea* spores .	15	2	13

In this unnaturally severe trial of the two treatments, spraying with a *P. gigantea* spore suspension proved to be much more effective than wedge inoculation, as was to be expected. The numbers of viable spores of *F. annosus* and *P. gigantea* in the respective suspensions were about equal; *F. annosus* has gained the ascendancy in one stump out of every six inoculated with the two fungi. Expectations from the earlier experiments with lengths of pine root and small stumps [Rishbeth (14) and (15)] were thus not fully realized. The important factor under natural conditions is probably the resistance of still living tissues in large stumps, which would tend to restrict growth of the purely saprophytic *P. gigantea* rather more than that of the facultative parasite *F. annosus*.

DISCUSSION AND CONCLUSIONS.

Several of the stump treatment experiments set up in East Anglia failed because the incidence of natural stump infection by *Fomes annosus* was very low at the time. To obtain satisfactory results from such experiments, adequate replication is clearly necessary. In any further work of this kind, experimental sites should be widely scattered because the incidence of stump infection by *F. annosus* differs

from place to place. Further, stump treatment should be carried out at different times at any one site, for instance, at 2- or 3-monthly intervals. Failing this, it might be possible to choose appropriate times by using existing information, admittedly scanty, about the relation of weather to *F. annosus* spore discharge [Rishbeth (15)].

Of the control methods so far described, protection of stump surfaces by covering with a tar/creosote mixture after all fellings, including final fellings, is thought the most promising. This gives an average of about 90 per cent. protection against infection by air-borne spores of *F. annosus* and is reasonably economical. Restriction or postponement of thinning, if feasible, would limit the amount of stump treatment necessary. The importance of carrying out such a treatment *immediately* after felling must be emphasized: in a moist atmosphere, spores of *F. annosus* alighting on stump surfaces germinate with little delay and the mycelium produced soon grows beyond the region reached by a surface protectant. Such growth may well be rapid if rain falls soon after felling, for spores may be washed at least 0·5 cm. into the tracheids [Rishbeth (15)].

As regards biological control of *F. annosus* by *Peniophora gigantea*, it is unfortunate that wedge inoculation is relatively ineffective, for suitable material is available in many conifer plantations. A spore suspension of *P. gigantea*, though only partially effective in stumps inoculated with large numbers of *F. annosus* spores, might prove completely effective against natural air-borne infection by *F. annosus*. It might also prove better than wedge inoculation in preventing growth of *F. annosus* into stumps from roots already infected, but it is doubtful whether the method could be made cheap and easy to apply. Nevertheless, biological control through *P. gigantea* is still of potential interest: simpler and cheaper means of encouraging the development of this useful fungus in pine plantations might be devised without the necessity for inoculating every stump. Further, biological control of this type might prove feasible with other tree-root parasites, especially where the crop is very valuable, and could be used either alone or as a supplement to stump poisoning.

Spread of infection in stumps from roots already containing *F. annosus* clearly cannot be prevented by surface protectants, nor as yet by any method of biological control. Control of disease caused by *F. annosus* is in fact all but impossible once the fungus becomes established on root systems.

IMPORTANCE OF CONTROL.

The importance of the damage can be over-estimated, but several features are disquieting. One is the relatively high proportion of alkaline and former arable soils, on which the disease tends to be severe; another is the great damage caused in reafforested sites on such soils. Even if damage is not unduly great in the first rotation, considerable loss may be encountered in subsequent ones on the same site. Largely through thinning, *F. annosus* is becoming established in numerous plantations where it was initially absent: the same thing must be occurring on an ever-increasing scale in recently afforested areas throughout Britain. As a result, butt rot is likely to develop over wide areas and killing may occur, in groups or

sporadically, on certain soil types. In such a situation, application of control measures becomes increasingly urgent. The cost of introducing reasonably effective control measures would be offset not only by the value of timber saved but also by reduced expenditure on other operations.

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WOOD-NAMES AND TREE-NAMES ON THE MAPS OF BRITAIN

By H. L. EDLIN

SUMMARY.

Woods and trees play an important part in the formation of the place-names found on topographical maps. The process of naming woods began in the earliest times and continues at the present day. Such place-names frequently provide information on the character of the woodland in the past, and are also deserving of study as a form of forest terminology. In Britain, place-names are derived from several linguistic sources, including Welsh, Gaelic, Anglo-Saxon, Scandinavian, French, Latin, and Modern English; consequently the name of a wood often provides evidence of the date of its recognition or formation. A glossary is given of 136 names of woods and trees which are represented on the maps of Britain.

TREES and woodlands, being conspicuous and fairly permanent natural objects, play an important part in the pattern of place-names whereby we identify localities. Moreover, many stands of forest trees, whether of natural or artificial origin, are large enough to merit a distinctive name of their own; such names may be applied either to a wood as a whole or to a certain portion of it. Pick up almost any sheet of a map of Britain, on any reasonably large scale, and you will find that a fair proportion of the place-names printed thereon will apply to woods that are still standing, or else be derived from trees or woods that once grew there and have since vanished. These wood-names and tree-names are sufficiently common and widespread to deserve attention with two objects in view. First, they may teach us something of the past history of the forests we tend today. Second, the study of forestry surely embraces the words that that science employs to express ideas, and hence the fully equipped forester may be expected to know something of the origin of place-names derived from trees or woodlands, or at least to recognize most such names at sight. But the political history of Britain, and the development of the English language, combine to make this study anything but a simple one. Seven main linguistic sources—Gaelic, Welsh, Anglo-Saxon, Scandinavian, French, Latin, and Modern English, contribute to the naming of the British countryside, and few foresters are familiar with more than two or three of these languages. My aim here is to identify and define the principal terms that have been used in the formation of place-names involving woods or individual tree species in various parts of the British Isles, mainly by means of a glossary.

The study of place-names is full of pitfalls, and often it is difficult, even for the expert, to decide which of two interpretations is the correct one. But where woodlands are concerned one portion of a name often reinforces another, lessening the possibilities of error; for example, the name 'Frithsden Beeches', which occurs in Buckinghamshire, embodies 'frith'—a forest, 'dene'—a wooded valley, and 'beech'—a common tree. So one is usually on fairly safe ground when picking out

such names—especially where there is physical evidence available in the form of an existing wood.

THE MAPS AND THEIR CONSTRUCTION.

Although the study of place-names extends to maps and records of all kinds, for most practical purposes the source of wood-names and tree-names is the Ordnance Survey series of maps, or other maps based on that survey. Between 1858 and the end of the nineteenth century most of the British Isles was surveyed on a scale of 1 : 2,500 or 25 inches to the mile; some of the less developed districts, however, were mapped on the scale of 1 : 10,560 or 6 inches to the mile. This 6-inch map is available for the whole country. It is the one most generally used by foresters, and also the most suitable as a source of wood-names. Little is gained, in this respect, by further reference to the larger 25-inch scale.

Of the smaller scales, the $2\frac{1}{2}$ inches to the mile (1 : 25,000) and the 1-inch to the mile (1 : 63,360), both show the names of the larger woods. Generally speaking, maps on a scale smaller than 1 inch to the mile are of little value for the study of wood-names, though the $\frac{1}{2}$-inch to the mile series published by Messrs. Bartholomew of Edinburgh carries a surprisingly large number of names of woods. The survey for the 1-inch Ordnance Survey series lasted from 1801 to 1870. This was the earliest comprehensive survey to show the boundaries and extent of woods accurately; on earlier maps they are little more than guess-work.

The original surveyors, who prepared the first Ordnance Survey maps, obtained and verified the names of each object shown, from knowledgeable local people. In Wales, and in those parts of Scotland where Gaelic place-names predominate, expert advice was obtained on the spelling of place-names in Celtic languages, and the versions printed are usually accurate. The spelling of place-names in English or Scots, however, is less subject to definite rules, and there must have been many instances where the name of a wood could not readily be verified from any written or printed source. It is, however, safe to assume that most names of actual woods found on the Ordnance Survey maps represent the words used colloquially for them in the nineteenth century. The spelling of the names of *towns or villages* derived from tree-names or wood-names was, however, based on written records; it does not always represent nineteenth-century pronunciation, and, in the case of Celtic names, is not always expressed in the standardized form of Welsh or Gaelic. These considerations seldom cause undue difficulty in practice, but account for many discrepancies between various spellings of words that are basically the same.

Revision of the Ordnance Survey maps goes on continuously, and occasionally new wood-names are added. But the general tendency is for woods that had a concrete existence and a name on the earlier maps to be swallowed by the spread of cities and their suburbs. Although the name sometimes survives the wood, both commonly disappear in this process.

Woods are distinguished on maps by two methods, used either separately or together. They may be shown by a distinctive colour, usually green, or by conventional symbols, usually little trees; or by both these devices. In many editions

this indication is carried to some definite fence boundary, shown by a printed line. But on the larger scales symbolic trees are sometimes sketched in, for example, along a wooded valley on an open moor, to indicate open woods that do not end along any definite fence line; this work is usually accurately done and was correct at the time of survey.

The Ordnance Survey varies its tree symbols to distinguish between coniferous, broadleaved, and—by a mixture of the two devices—mixed woods. Although here again the work was carefully done at the time of survey, its interest nowadays is mainly historical, as replanting has so often occurred since then. The 25 inches to the mile scale occasionally shows large individual trees that were important as check-points in the survey and even states their species; but one is lucky to find these veterans still standing today.

A point of interest is that quite small woods, often of only a few acres extent, are named on the maps. Woodland was favoured in this respect, for although in many districts each farm field has a local name, the surveyors were not instructed to record field-names unless they applied to exceptionally large or unusual areas.

CELTIC PLACE-NAMES—GAELIC AND WELSH.

At the dawn of recorded history, the whole of Great Britain and Ireland was occupied by Celtic peoples who had been established there for several centuries before the birth of Christ. Every important natural feature had then its appropriate name in one Celtic dialect or another, but over the southern and eastern portions of the mainland these have since been replaced, in whole or part, by the names imposed by later invaders. Nevertheless, Celtic place-names still predominate in Ireland and over half of the mainland of Great Britain. The pure Gaelic names are found in Ireland and the Highlands and western islands of Scotland; names of Gaelic derivation are widespread over the rest of Scotland and occur sparingly in the northern English counties; an allied dialect, Manx, supplies many of the place-names of the Isle of Man. Welsh accounts for the bulk of the place-names of modern Wales; and Cornish, though no longer actively spoken, for those of Cornwall. As one goes east, the influence of Welsh and Cornish, which are allied tongues, diminishes; it remains strong in the border counties, such as Shropshire, Herefordshire, parts of Gloucestershire, and Devon; but is virtually absent when the east coast is reached.

A fairly constant feature of these Celtic tongues is that the adjective follows the noun which it qualifies. Thus, in Fforest Fawr, Welsh for 'great forest', *fawr* is the adjective 'great', qualifying the noun *fforest*.

A further and more remarkable feature is the variation, under certain grammatical rules, of many initial consonants; both sound and spelling may change. For example, *coed*, the Welsh for 'wood', is in certain contexts spelt and pronounced *goed* or *nghoed*. This feature is called 'mutation' in Welsh and 'aspiration' in Gaelic. In the latter language the letter *h* is added to the initial consonant, and has the effect, for example, of softening the *b* sound of *beith*—birch—to *bheith*, pronounced *vey*.

The spelling of Gaelic names follows rules that make the pronunciation of the words difficult for the English reader to grasp. Consequently many place-names exist in an anglicized form. 'Leven', for example, is the anglicized version of Gaelic *leamhan*, meaning 'elm'. Welsh place-names, however, are seldom anglicized where they occur in Wales, though the spelling of Welsh survivals in England naturally tends to vary from standard Welsh orthography. Such survivals commonly relate to natural objects, such as rivers, hills, or forests. Wiltshire, for example, has a River Avon (Welsh, *afon* = river) and two villages called Bedwyn (Welsh, *bedwen*, birch-tree). The plural of Welsh words takes varied forms, and the names of trees are often cited in a plural sense; thus *derw* means oak-trees, but has a 'singulative number', *derwen*, a (single) oak-tree.

When such considerations are kept in mind, these Celtic place-names are fairly easy to interpret, as the languages have been subject to comparatively little change over the centuries. Likewise, the districts in which they occur have been the least modified by human activity. The wood called *darach* in the west of Scotland today may have been an oak wood—as its name signifies—when the first Celtic settler gave it that name perhaps two thousand years ago. Of course, Celtic names for woods, in districts where Welsh or Gaelic are still spoken, may be of modern origin, but as a rule the probabilities are against this. Celtic names in English-speaking districts are usually of great antiquity and afford some evidence of the nature of woodlands prior to the Teutonic invasions between A.D. 420 and 1263.

TEUTONIC PLACE-NAMES—ANGLO-SAXON AND SCANDINAVIAN.

Between A.D. 420 and 1263 the British Isles were subject to invasion and settlement by Teutonic peoples from northern Europe whose languages provide the basis of modern English and form the main source of place-names in the south and east of Great Britain. There is not space here to discuss the complex pattern of their settlement, and for our purpose it is only necessary to distinguish two groups of Teutonic dialects. The first of these, Anglo-Saxon, was spoken by the earlier arrivals who settled in most parts of England, excepting Cornwall, and also in the south-east of Scotland. The second, which we can broadly term Scandinavian, was spoken by the Norsemen and Danes who arrived from the ninth to the eleventh centuries in England and as late as A.D. 1263 in Scotland. These Scandinavians were masters of both the western and eastern seaward approaches to Britain, and consequently their place-names have a wider and less regular distribution than those of the Anglo-Saxons. Scandinavian place-names predominate in the Orkney and Shetland Islands, which were Norwegian possessions until 1469, and in Caithness, and are common over most of the eastern seaboard of Scotland; they also occur in the Hebrides and down the west coast of Scotland, with a few outliers in Galloway. In England they are very common in Cumberland and the Lake District generally, and are quite frequent in Northumberland, Durham, Yorkshire, Westmorland, and Lancashire; farther south they occur, though more sparingly, in the eastern and east midland counties, while a few examples occur elsewhere, even in such isolated areas as West Wales.

Many root words are common to both Anglo-Saxon and Scandinavian languages, so that in some cases it is hard to say whether a place-name is derived from one or the other—or possibly from both; but other words are characteristic of one group or the other. For example, 'wood', with its variations 'weald' and 'wold', is typical of Anglo-Saxon, while 'thwaite', implying a woodland clearing, is representative of the Scandinavian group.

Almost every tree native to Britain is found also in the European homelands of these Teutonic invaders, and consequently they applied Teutonic names to nearly all our trees. Yew, which retains its Welsh name, is the only important exception. In most areas of Teutonic settlement, Teutonic words for woods, such as 'wood' itself, 'shaw', and 'dene', took the place of whatever Celtic words had previously been used. But although the Celtic and Teutonic tree-names and wood-names were mutually exclusive, they had one feature in common. Both were applied to natural woodlands. They describe woods in terms of the kinds of trees growing there, or by reference to some feature of situation or ownership, but they do not appear to give any hint of their method of management.

ROMANCE PLACE-NAMES—FRENCH AND LATIN.

If one excepts the Channel Islands, place-names of French derivation were unknown in the British Isles before A.D. 1066, the date of the Norman invasion of England under William the Conqueror. In England, at least, French words for woods are now quite common, and the interesting point from the forester's angle is that they usually give some clue to the management of the woods involved. This management might be for sport, as with 'forest', 'chase', and 'warren'; for the control of livestock, as with 'park'; or for more definitely silvicultural reasons as with 'coppice'. Even the Scots, who have few French place-names, adopted the French word *policy* to cover the planned woodlands around their mansion houses.

But although Norman-French has been a prolific source of names for woods, it has contributed very few, if any, place-names involving specific kinds of trees. Only in the Channel Islands are French names used for trees; all the customary French words apply except that for oak, which is *quêne*, instead of *chêne*. The place-names of these islands are almost entirely French in origin, but trees seldom figure in them.

The influence of Latin on our woodland names has been an indirect one, exercised through the medium of French and Modern English. Words such as *foresta*, a forest, and *boscus*, a wood, are not to be found in the classical Latin of the ancient Romans. They cannot be traced farther back than the medieval or 'late' Latin of the ecclesiastical scribes. Indeed, they may not be true Latin at all, but only the latinized forms of words indigenous to other languages. Nevertheless, certain of our names for woods do have ultimate Latin roots. As in the case of French, Latin words for tree species do not figure in our place-names.

MODERN ENGLISH.

Most of the new woods established over the past 400 years have been named in terms of Modern English, which helps, in many cases, to date them. Typical

modern names are 'plantation' and 'enclosure', both popular in the eighteenth century. Even 'forest', though of Old French origin, has its modern implication, which is substantially different from the unenclosed hunting-ground of a Norman king. 'Pine' and 'larch', both found in modern place-names, are quite new words in our language; while 'fir', though of ancient derivation, has only been applied to woods in the south of England during the past 300 years. Occasionally, too, one comes across a 'Waterloo Wood' or a 'Jubilee Plantation', which carries the date of its formation in its name. The naming of new woods still goes on and must, of course, continue as long as they are made; but many of these new descriptions are only known locally and may take a long time to reach the map. Every year the Forestry Commission names a number of recently formed forests, and many of those in Wales have received Welsh titles; sometimes an old name is perpetuated, but in other cases an entirely new combination has been formed.

REPETITION IN WOODLAND NAMES.

A frequent feature of the names of woods is the repetition of the implication 'woodland'. A simple example is 'Frith Wood', which is part of Bedgebury Forest in Kent. In Saxon times it was doubtless called *fyrhth*, meaning 'forest'; but as time went on people forgot that the modern version of that name, 'frith', meant 'forest', and felt it necessary to add the word 'wood'. Often, too, the name of a particular kind of tree is incorporated, as at Ashurst Wood in Hampshire, which is 'the wood of the wood of ash trees'; this doubtless arose because 'Ashurst'—'wood of ash-trees', had become the name of a village, and in that case the name of a place, itself derived from a wood, was later used to distinguish a particular stretch of woodland nearby. Although at first sight these repetitive names—or 'doublets' as the philologists call them—seem to get us nowhere, they do prove, for example, that there was woodland at Bedgebury and Ashurst in Saxon times as well as at the present day, and suggest that forest cover of some kind has existed there continuously. The tree-names, as at Ashurst, also suggest which trees predominated in early times. Often these doublets involve two linguistic sources; 'copsewood', for example, is from French *couper*, to cut, and thus a wood that is regularly cut, and Anglo-Saxon *wald*, a wood.

A GLOSSARY OF TREE-NAMES AND WOOD-NAMES.

The glossary that follows has been compiled by reference to Ordnance Survey maps of representative districts of England, Scotland, and Wales, and is thus fairly comprehensive in its representation of the various languages that contribute to British place-names. But there are, no doubt, a number of other local terms that are used to denote woods as such, rather than to describe some particular feature of an individual wood, and readers may care to report them. It is hoped, in this way, to complete the list of wood and tree elements in our place-names, to the mutual benefit of foresters and students of language.[1]

[1] Correspondence on this subject should be addressed to Mr. H. L. Edlin, 86 Windermere Road, Coulsdon, Surrey.—Ed.

AFAL. Welsh, apples; singulative *afallen*. Found at Maesafallen—field of the apple-tree—south of Bala, Merioneth.

AITHIN. Gaelic, furze, also juniper. The River Nethan, a tributary of the Clyde, is derived from *avon nethin*, the river of furze.

ALDER. Anglo-Saxon *aler*; *Alnus glutinosa* Gaertn. Common in place-names, as Alresford, Hampshire. See also CARR and GWERN.

ALLOTMENT. Modern English, land allotted to an individual. The share apportioned to a right holder at the enclosure (q.v.) of a common was sometimes termed his 'allotment'. Occurs in Dorset.

ALLT. Welsh, wooded cliff; a mutation of *gallt*, q.v. Not to be confused with Gaelic *allt*, a hill stream.

APPLE. Anglo-Saxon *æppel*; *Malus pumila* Miller. As at Eppleton, Durham.

ASH. Anglo-Saxon *æsc*; *Fraxinus excelsior* L. Common in place-names, as at Ash, Surrey.

ASPEN. Anglo-Saxon *æspe*; *Populus tremula* L. Occurs at Aspley in Bedfordshire.

BEAT. Anglo-Saxon *beatan*, to strike. The round or course of a gamekeeper or forester, and hence the ground entrusted to his care.

BEDW. Welsh, birches; often mutated to *fedw*; *bedwen*, birch-tree, is the singulative form. An interesting Celtic survival is the village name of Great Bedwyn in Wiltshire. Common in Wales, as at Fedw, near Corwen, Merioneth; and Coed Bedw, near Rogerstone, Monmouthshire. In the name Michaelston y Vedw, Monmouthshire, the spelling has been anglicized from *Fedw*.

BEECH. Anglo-Saxon *boc*; *Fagus sylvatica*, L. Common in the south of England, as at Burnham Beeches, Buckinghamshire.

BEITH. Gaelic, birch. As Beith, Ayrshire. Auchenvey, Galloway, is from *achadh na bheith*, field of the birches, the *b* being aspirated to a *v* sound.

BELT. Anglo-Saxon, a band or girdle. A plantation formed in the shape of a narrow band, such as a shelter belt to resist the wind. The word is frequent on maps of the Thetford district in Norfolk, where such belts were planted in the nineteenth century to shelter agricultural land; many of these belts have since been merged in Thetford Chase Forest.

BIRCH. Anglo-Saxon *birce*; *Betula pendula* Roth. or *B. pubescens* Ehrh. Widespread, as at Birch, Manchester.

BIRK, Scandinavian *birk*, birch. The usual form in Scotland and northern England; as the Birks of Aberfeldy, Perthshire.

BOIS. French, wood. Uncommon; occurs at Theydon Bois, adjoining Epping Forest in Essex; is there pronounced 'boys' which is said to be the old Norman-French pronunciation, unlike the modern French *bwa*.

BOX. Possibly Anglo-Saxon, from German, *Buchs*; *Buxus sempervirens* L. An unusual place-name, as box is a rare shrub. Found at Box Hill, Surrey, and Box, Wiltshire.

BRAKE. From Low German *brake*, brushwood; a place overgrown with low bushes or brambles. Found at Furze Brake, north-west of Clifton Hampden, Oxfordshire. The same word is used overseas for a dense growth of sugar-cane, &c., as in the phrase 'cane brake'.

BREN. Welsh, tree. A mutation of *pren*, q.v.

BUSH. Medieval Latin *boscus*, a wood. Land covered with shrubs or small trees. As Bushy Bratley, in the New Forest, Hampshire.

CALL or CALTUINN. Gaelic, hazel. As at Caldons, a hazel wood in Glen Trool, Kirkcudbrightshire.

CANT. Origin uncertain. Used in Kent to denote a section of a coppice on which the crop is sold as one lot, for cutting at one time.

CAORTAINN or CAORUNN. Gaelic, rowan. As at *Gleann nan Caorunn*—glen of the rowans—by Glen Falloch, Argyll. Sometimes aspirated to *chaorunn*.

CARR. Anglo-Saxon, marshy woodland. The typical carr tree is the alder, and this still dominates many marshy woods, such as Carrswood, in south Manchester. The name is also common in the fenland districts of east England, where clearance has left some of the carrs treeless.

CELLI. Welsh, grove or small wood. Plural *celliau* or *cellioedd*. Often mutated to *gelli*. Common throughout Wales, as at Gelli Lydon, near Trefriw, Caernarvonshire. Cognate with Gaelic *coille*, q.v.

CELYN. Welsh, holly trees. Singulative is *celynen*. Found at Llwyn Celyn—holly grove—near Llanvihangel Crucorney, Monmouthshire.

CHART. Anglo-Saxon *ceart*, rough common land. A usual term in Kent and Surrey for commons, such as Westerham Chart, Kent; several of these lie on the Greensand formation and are fairly well wooded.

CHASE. French *chasse*, a hunt. Land over which hunting rights were exercised by a nobleman or a dignitary of the Church, as opposed to a Royal Forest, where hunting rights were held directly by the king. As Cannock Chase, in Staffordshire.

CLEUCH (Scots) and CLOUGH (English). Probably from Anglo-Saxon *clo*; connected with cleft and Dutch *kloof*. In the north of England, where this word is pronounced 'cluff', it is the usual name for wild ravines in the hills, which are still wooded and have probably always been so. As Wildboarclough, near Macclesfield, Cheshire.

CLUMP. Low German *klump*, a cluster of trees. Most woods called 'clumps' are of fairly recent origin. The planting of such groups, as landmarks on hill-tops, was fashionable in the early nineteenth century.

COED (plural COEDYDD). Welsh, a wood. The usual name in Wales for any tract of woodland. An example is Coed Cadwgan, near Lisvane, Glamorgan. Recently the Forestry Commission has applied the word to modern forests, such as Coed y Brenin—the King's Wood—in Merioneth. English derivatives are *cote*, *sheet*, *shoot*, and *shot*, q.v. A common Welsh mutation is *goed*, as at Parc y Derw Goed—park of the oak wood—north of Llandderfel in Merioneth.

COEDEN. Welsh, a tree.

COEDLAN (plural COEDLANNAU). Welsh, a plantation.

COEDWIG (plural COEDWIGOEDD). Welsh, a forest.

COILLE. Gaelic, a wood. Frequent in the Scottish Highlands; often anglicized as *killie*, q.v., or as 'coil'. Examples are Coille Chreagain—wood of the crags—by Strathyre, and Coilmore, on Loch Earn, both in Perthshire. Sometimes aspirated to *choille*.

COLLEN. Welsh, hazel-tree; the plural is *cyll*. Found at the Afon Collen—river of hazels—Llangerniew, Denbighshire.

COMMON. Latin *communis*. Land used in common by one or more people, for such purposes as grazing. The legal position of such commons varies. Common grazing rights may be owned by numerous freeholders, and in such cases a special Act of Parliament may be needed to inclose any of the land for agriculture, forestry, or other purposes. Many such Acts of Inclosure were passed in the eighteenth and nineteenth centuries, with the object of securing better use of the land. The name 'common' is often applied to rough land over which no valid common rights now subsist; and such land has often been used for afforestation.

COMPARTMENT. Modern English. A portion of a wood, usually from 20 to 30 acres in area,

treated as a unit for purposes of management. This usage of the word is derived from modern French, and is not found outside forestry circles. Compartments are usually numbered serially within a forest, and bear no names.

COPPICE. From French *couper*, to cut: wood cut over at intervals. This name is very common throughout the south and midlands of England. The term is applied by foresters to the system of management under which woods are cut over at intervals of from 1 to 20 years, to provide small poles; the usual species are hazel, hornbeam, sweet chestnut, oak, and ash. This has been a widespread system from medieval times, and most woods now called *coppice* were once so worked. Many have since been converted to High Forest.

COPSE. A common alternative spelling of *coppice*, q.v. Found at Copse of Linwood, New Forest, and generally throughout England.

COTE. From Welsh *coed*: a wood. Found at Woodcote near Purley in Surrey.

COVERT. Old French, from *couvrir*, to cover. Thick woodland or shrubbery providing hiding-places for game. As Fox Covert, west of Chalgrove, Oxfordshire. Sometimes pronounced as 'cover'.

CRAB. Anglo-Saxon *scrob*, low stunted tree. Commonly applied to the wild apple, *Malus pumila* Miller. Found at Crab Orchard, south of Verwood, Dorset.

CRANKIE. Anglicized spelling of Gaelic *critheanach*, the aspen, *Populus tremula* L. Found at Killiecrankie, Perthshire—wood of the aspens. *Critheanach* means literally 'the quivering tree', an allusion to the constant trembling of the aspen leaves. Compare the Welsh folk name *coed tafod merched*, tree of the woman's tongue.

CRANN. Gaelic, tree, log, mast, or roof timber. Not very common in place-names, but occurs in Druim nan Crann Saeghde—ridge of the tree of arrows—by Loch Rannoch, Perthshire. *Crann* is cognate with Welsh *pren*, q.v., the substitution of *c* for *p* being a common difference between the two Celtic tongues.

CRITHEANACH OR CRIOTHACH. Gaelic, aspen. Found at Creich, Sutherland. See also CRANKIE.

DARACH. Gaelic, oakwood. As at Killdarroch, Ayrshire, from *coill darach*, wood of oaks.

DEN, DENE. Anglo-Saxon *denu*, a (wooded) valley. Common in both Scotland and England, as at Hawthornden, Midlothian, and the Forest of Dean, Gloucestershire.

DERRY. Usually from Gaelic *doire*, q.v., a grove; but sometimes, from Gaelic *darach* or Welsh *derw*, oak or oakwood. 'Derry' is a common constituent of Irish place-names, such as Londonderry; it is also found in Wales, at Derry Ormond, Cardiganshire.

DERW, Welsh, oakwood. Frequent, as at Llwyn Derw—oak grove—south of Welshpool, Montgomery. *Derwen* is the singulative form, while *derwin* signifies 'made of oak'. *Derwydd* refers to the ancient druids, who practised their rites in oak groves.

DINGLE. Possibly a diminutive form of *dene*, q.v. A narrow, secluded valley embowered with trees. Found in Herefordshire, as at Pentre Coed Dingle, north-west of Eardisley.

DOIRE. Gaelic, a grove or thicket. Often anglicized as 'derry'. Found at Doire Darach—oak grove—by Loch Tulla, Argyll.

DRAIGHEAN. Gaelic, blackthorn. As at Mildriggen, Wigtownshire.

EIK. Scandinavian, oak. Found at Eyke, Suffolk.

ELM. Anglo-Saxon, *ælm*, *Ulmus* spp. Frequent in England, as Elmstead Woods, Kent.

ENCLOSURE. Modern English: land inclosed from open country. Common and widespread. During the eighteenth and early nineteenth centuries numerous Acts of Inclosure were passed, under which commons were inclosed and apportioned to the various landowners and commoners who previously held rights over them. Inclosures are often named after the man who made them, as Gundry's Enclosure, near Wimborne, in Dorset. Also spelt *inclosure*, q.v.

FEARN, Gaelic, alder. As at Sloc nam Fearna—hollow of the alders—in Kintyre, Argyll.

FEDW. Welsh, birches, mutation of *bedw*, q.v.

FELL. Scandinavian *field*, mountain or rock. The usual name for a hill in the north of England. Though fells are usually grassland they may be wooded, as at Ausin Fell Wood, near Claife, Lancashire.

FFOREST. The Welsh form of English *forest*. Common in place-names, as at Coed y Fforest —forest wood—near Llanharry, Glamorgan.

FIELD. Anglo-Saxon *feld*. An inclosure, usually for agriculture. Many fields have subsequently been afforested, as at Northfield Wood, near Stowmarket, Suffolk. In Malaya the word is used to imply a compartment (q.v.) and a 'field' in a rubber plantation is commonly stocked with tall trees.

FIR. Anglo-Saxon *fuhr*; *Pinus sylvestris* L. 'Fir' is still a colloquial name, both in Scotland and England, for the Scots pine. Woods known as 'firs' are fairly frequent in the south of England, but it is improbable that any are much older than A.D. 1600. Most of these pine or fir plantations were established in the eighteenth and nineteenth centuries. An example is Kingswood Firs, near Grayshott, Surrey.

FOREST. Medieval Latin *foresta*. This latter word does not occur in ancient Roman Latin, and has not been traced back beyond the reign of Charlemagne, in the ninth century A.D. It may be a latinization of a Frankish word resembling Anglo-Saxon *fyrhth*. *Foresta* is also the root of Modern French *forêt* and Modern German *Forst*. In Britain it has four main shades of meaning:

(*a*) Any extensive stretch of land covered with trees, such as the Black Forest of Germany.

(*b*) A unit of management of the State woodlands, such as Kielder Forest, Northumberland.

(*c*) An ancient royal hunting ground, subject to special laws, such as the New Forest, Hampshire.

(*d*) A stretch of wild country in private ownership, used for raising and stalking deer; this usage is found mainly in Scotland, and an example is Reay Forest in Sutherland; some such 'deer forests' are almost treeless.

'Forest' is a common element in English place-names; Forest Row, Sussex, lies on the outskirts of Ashdown Forest, but Forest Hill, London, is in a suburban district now devoid of woodlands. A unique example is Forest, the name of a parish in Guernsey, Channel Islands, which preserves the Norman French spelling, distinct from Modern French *forêt*.

FRITH. Anglo-Saxon *fyrhth*, woodland; Gaelic *fridh*, a forest; and Welsh *ffridd*, sheep-walk. A very interesting word, which is probably cognate with our modern 'forest' (q.v.), although we get the latter through another channel. It is surprising to find a word so similar in three basic languages; the actual pronunciation of *frith*, *fridh*, and *ffridd* is virtually the same.

I have no Scottish record of a wood-name involving *frith*. In Wales *fridd* is common, but is nowadays usually applied to the inclosed portion of a sheep-walk. In England, *frith* is exceptionally common and widespread. A well-known example is Chapel-en-le-Frith, in the Peak District of Derbyshire. Other counties in which it occurs are Yorkshire, Bucks., Kent, Surrey, Sussex, Hants, and Monmouth. It is often associated with large blocks of woodland that may well have remained as such since Saxon times. A Welsh example is Fridd Fawr, now largely afforested, beside Lake Vyrnwy in Montgomery.

GALLT. Welsh, wooded hill-side or cliff. Often mutated to *allt*, plural *elltydd*. As at Gallt y Pandy—wooded slope of the fulling mill—and Tan yr Allt—end of the wood-slope—south of Bettws y Coed, Caernarvonshire.

GELLI. Welsh, a grove; a mutation of *celli*, q.v.

GIUTHAIS. Gaelic, pine; *Pinus sylvestris* L. Fairly common in the place-names of the Scottish Highlands, but often with an anglicized spelling. Examples are Guisachan—the pine wood—and Kingussie (*ceann guisachie*)—the end of the pinewood—both in Inverness-shire.

GOED. Welsh, wood. Mutated form of *coed*, q.v.

GROVE. Anglo-Saxon, *graf*: a thicket. May be applied to any wood, such as the extensive Grovely Wood in Wiltshire, but in modern usage often implies a small wood or group of trees.

GWERN. Welsh, alder. May imply an existing alder wood or a swamp from which the alders have been cleared, as with *carr* (q.v.). Often mutated to *wern*. Examples are: Y Gwernydd, south-west of Welshpool, Montgomery, and Wern Fawr, near Eglwys Fach, Denbighshire.

HANGER or HANGING. Anglo-Saxon *hangen*, to hang. A wood growing on a steep slope. Common in Hampshire, as at The Hanger, near Selborne, mentioned by Gilbert White; and Baker's Hanging, a wood on sloping ground north-west of Ringwood.

HAUGH. Teutonic, but derivation obscure; connected with German *Hage*, hedged pasture. 'Hough', common in Lancashire and Cheshire, as at Hough Green in both counties, and 'heugh', found in Northumberland, as at Redheugh, Tarset, are variants. Although at the present day 'haugh' implies a valley pasture in the north of England, it is often associated with woodland, as at Bilhaugh, near Ollerton, in Sherwood Forest, Notts.

HAWTHORN. Anglo-Saxon *hagathorn*; Scandinavian, *hagtorn*; *Crataegus monogyna* Jacq. As at Hawthornden, Midlothian.

HAYE. Connected with *haugh*, an enclosure, q.v. A common name for woodland in and around Staffordshire; as at Hopwas Hays Wood, near Tamworth.

HAZEL. Anglo-Saxon *hæsel*; *Corylus avellana* L. Common in England, as Haslemere, Surrey.

HEATH. Anglo-Saxon, *hæth*, a heath. A stretch of open country with a vegetation consisting largely of heather, *Calluna vulgaris*, or heaths of the genus *Erica*. Such land is often selected for afforestation, as at Ashley Heath, near Ringwood in Hampshire. Wood-names embodying 'heath' are common in Surrey, as at Highdown Heath, near Hambledon.

HOLM. Anglo-Saxon *holen*, holly; *Ilex aquifolium* L. Many 'holms' in the New Forest, such as Shirley Holms, are still holly thickets.

HOLT. Anglo-Saxon, a wood. A widely distributed name in England, as at the village of Holt, near Wimborne in Dorset. Cognate with German *holz*, wood.

HURST. Anglo-Saxon *hyrst*: wooded hill. A common constituent of place-names in Kent, Sussex, and Hampshire, as Hawkhurst, Midhurst, and Brockenhurst. These towns lie in districts that are still well wooded today.

INCLOSURE. Alternative spelling of *enclosure*, q.v. This form was adopted for certain Acts of Parliament; hence we get Knightwood Inclosure, and others in the New Forest, Hampshire.

INTAKE. English, land 'taken in' from open moorland. Equivalent to inclosure, q.v. Common in hill country throughout the north of England, as at Didsbury Intake, in Longdendale, Cheshire.

IUBHAR. Gaelic, yew. Found in anglicized form at Urie, Aberdeenshire, and Palnure—from *pol na' iubhar*—pool of the yew-trees, in Kirkcudbrightshire.

JUNIPER. English, *Juniperus communis* L. Found at Juniper Green, Midlothian, Juniper Valley, south of Godalming, Surrey, &c.

LEAMAN. Gaelic, elm. The Scots elm, *Ulmus glabra* Huds., is native to Scotland, and figures frequently in place-names. Lomond, found at Loch Lomond, and also in the Lomond Hills of Fife, is probably from this source. Leven, in Fife, and the River Leven —the outlet from Loch Lomond—are from the aspirated form *leamhan*.

LIND. Anglo-Saxon, lime-tree; *Tilia* spp. Uncommon, but found at Lyndhurst, Hampshire.

LLWYN. Welsh: a grove. Occurs fairly frequently in Welsh place-names, such as Llwynypia, the grove of the magpie, in Glamorgan.

MAPLE. Anglo-Saxon *mæpel*; *Acer compestre* L. As Mapledurham, Oxfordshire.

OAK. Anglo-Saxon *ac*; *Quercus robur* L. and *Q. petraea* Lieb. Common in England, as Oakhampton, Rutland.

ONN. Welsh, ash-trees, with a singulative form *onnen*, ash-tree. As at Tair Onen, near Cowbridge, and Cefn On—ridge of the ash-trees—south-east of Caerphilly, both in Glamorgan.

ORCHARD. Anglo-Saxon *ortgeard* (literally wort-yard), an inclosure devoted to the cultivation of fruit-trees. Sometimes found in the sense of a natural grove of fruit-bearing trees. As at Crab (Apple) Orchard, south of Verwood, Dorset; also at Merry Orchard, Minstead, Hampshire, where 'merry' signifies French *merisier* or wild cherry, *Prunus avium* L.

PARC. Welsh form of *park*. Common. Often still used in the original sense of an enclosure, usually for sheep. The plural is *parciau*. An example is Parc Carrog—park of the rocks—west of Glyn Dyfrdwy, Merioneth.

PARK. Anglo-Saxon *pearroc*, French *parc*. Common and widspread. Implies an inclosure, made in open country, usually to contain cattle, sheep, or deer. Such parks were commonly made around manor-houses, and were developed, especially in the eighteenth century, as landscape areas or pleasure grounds. Hence the modern 'public parks'. Many parks contain fine specimen trees. The Scottish equivalent is *policy*, q.v.

PEAR. Anglo-Saxon *peru*, *Pyrus communis* L. Found at Perrywood, New Forest, and elsewhere.

PIECE. Modern English. Signifies the piece or share allotted to an individual at the enclosure of a common. Found at Poors Piece, near Christchurch, Hants.

PINE. Latin, *pinus*. Found mainly in England, where it indicates woods of fairly recent planting, pines being uncommon before the eighteenth century.

PLANTATION. Modern English, from Latin *planta*, a plant. A wood established by planting. This word became very popular in the eighteenth century, and broadly speaking most instances of the word as a place-name apply to woods created artificially in the eighteenth and nineteenth centuries. Common and widespread.

POLICY. Old French *policie*, the art or manner of governing or management, hence, possibly, managed grounds. In this sense, *policy* (plural *policies*) is found only in Scotland, but is there general. It embraces all the pleasure grounds around a mansion-house, and has a similar, but rather wider, meaning than the English 'park', q.v. The term is probably of medieval introduction, like other French words in the Scots tongue.

POLLARDS. From Low German *polle*, the head. A pollard tree is one that has been 'beheaded' by cutting off the trunk at a convenient height, usually 6 to 10 feet above ground level. The young shoots that grow out are safe from grazing cattle and are used for firewood, browse, or basketry. Examples are willow in Thames valley, hornbeam in Epping

Forest, beech in New and Dean Forests. Occurs as a wood-name at Pollards Wood, north of Chalfont St. Giles, Buckinghamshire.

PREN. Welsh, tree, wood or roof-timber. Mutates to *bren*, and has plural forms *prennau* and *preniau*. Uncommon as an element of place-names, but a *breninbren*, or 'king tree', once stood at Ganllwyd, near Dolgelley, Merioneth. *Pren* is cognate with Gaelic *crann*, q.v.

ROUGHS. Anglo-Saxon *ruh*, rough. Uncultivated ground overgrown with shrubs, &c. As at Parkgate Rough, near Linch, Sussex.

ROWAN. Scandinavian, *rönn*; *Pyrus aucuparia* L. Occurs chiefly in the north, as at Rowan-tree, in the Glen Trool National Forest Park, Ayrshire.

SAILEACH. Gaelic, willow. As at Salachan, Argyll; see also SHELLACH.

SAUCH or SAUGH. Scots, willow. As at Sauchiehall, near Glasgow.

SCRUB. Anglo-Saxon *scrob*, low stunted trees or underwood. Found at Wormwood Scrubbs, an open space in north-west London.

SGITHEACH. Gaelic, hawthorn. As at Sheoch in Stirlingshire.

SHAW. Anglo-Saxon *scaga*, also Scandinavian *skoga*, a wood. This word, which is cognate with the modern Norwegian *skog*, is very common in place-names in the north of England and in those parts of Scotland where Norse influence was strong. It is still colloquially used for woods in Scotland, while English examples are Scafell in Cumberland and Ickornshaw—the acorn wood—in Yorkshire. In the south of England it is uncommon, but examples occur in Surrey, such as Coldroast Shaw, near Coulsdon.

SHEET. From Welsh *coed*, a wood. Occurs in Dorset, at Whitesheet Plantation, near Ferndown, and is a variation of *shoot* and *shot*.

SHELLACH. Gaelic, *saileach*, willow. Found at Achnashellach, Ross-shire—the field of the willows.

SHOOT. From Welsh *coed*: a wood. Occurs at Cockshoot in the Forest of Dean, Gloucestershire. Also at Chute Forest in Wiltshire.

SHOT or SHOTT. From Welsh *coed*: a wood. A common constituent of place-names, such as Aldershot, in Surrey and Hampshire. No satisfactory Anglo-Saxon root has been found for it, and it seems to be a genuine Celtic survival.

SHRUB. Anglo-Saxon *scrob*, a bush. Found at Repton Shrubs, near Repton, Derbyshire.

SILVA. Latin, a forest. Rare, but found at Silver Street, in Kent, associated with a Roman road.

SLAD or SLADE. Probably of Anglo-Saxon derivation. The usual term for wooded valleys in the Cannock Chase district of Staffordshire, as at Hazelslad. Also occurs at Slade, south Manchester, and Genesis Slade in Epping Forest, Essex.

SLING. A long narrow belt of woodland. A local term found in Herefordshire.

SPINNEY. Old French *espine*: a cluster of thorny bushes. Now applied to a small wood or thicket. Fairly common in England.

STRIP. Scandinavian *stripe*, long narrow piece. A wood named from its shape, as Cistern Strip, near Peebles.

THICKET or THICKS. Anglo-Saxon *thiccet*, a wood of thickly set trees. As at Havant Thicket, in Forest of Bere, Hampshire.

THORN. Anglo-Saxon. Wood of hawthorn (q.v.) or blackthorn, *Prunus spinosa*. As at James Thorns, New Forest.

THWAITE. Scandinavian, a clearing or settlement in a wood. Very common in the Lake District, as at Thornthwaite in Cumberland. Occasional elsewhere in the north of England.

TREE. Anglo-Saxon *treo*. Tree or timber. Common in place-names; an example is Saughtree, near Newcastleton in Roxburghshire. The prefix 'tre', very common in Welsh and Cornish place-names, is short for *tref*, a village; but Tresta, in the Shetland Islands, is from Icelandic *tre staör*, or 'tree place', trees being rare in the Shetlands.

TRUIM. Gaelic, elder. Found at Truim, Inverness-shire.

UINSSE. Gaelic, ash. Found at Killyminshaw in Dumfriesshire, from *coille nam uinsse*, wood of ash-trees.

URE. Anglicized spelling of Gaelic *iubhar* (q.v.), yew.

VEDW. Anglicized spelling of Welsh *fedw*, a mutated form of *bedw*, birch tree, q.v.

VERT. French, *vert*, green. The term used in the Norman forest laws for the pasturage of a forest. Hence *verderer*, an officer concerned with its preservation. Occurs at Vert Wood, near East Hoathly, Sussex.

WALK. Anglo-Saxon *wealcan*, to walk. That part of a forest walked over by a forester or keeper, as Rhinefield Walk in the New Forest.

WARREN. Old French *warenne*. Ground used for breeding and preservation of rabbits. Like the rabbit itself, this word seems to have been brought in by the Normans. Common in the Thetford district of Norfolk, where many warrens have been afforested after the extermination of the rabbits. Also found at The Warren, near Groombridge, Sussex.

WEALD. Anglo-Saxon, *wald*: a wood. The best known instance of this name is the great Weald of Kent, Surrey, and Sussex, an extensive tract of land lying between the North and South Downs, which is still one of the most densely wooded areas of England.

WERN. Welsh, alder, mutated form of *gwern*, q.v.

WILD or WILDERNESS. From Anglo-Saxon *wilder*, wild animals. Uncultivated and uninhabited country, as at Ashley Wild Ground, near New Milton, Hampshire. In a later usage, implying a portion of a garden where things are planted to grow without cultivation, *wilderness* is sometimes found on maps of estate woodlands.

WILLOW. Anglo-Saxon *welig*; *Salix* spp. As at Newton-le-Willows, Lancashire.

WITHY. Anglo-Saxon *withig*, Scandinavian *vith*, a willow, *Salix* spp., and particularly one of the osier group used for tying or basketry. Withybeds are common in many districts, especially so in valleys near fishing-villages, where withies are used for lobster pots and creels. Examples are Withybed Copse, beside the Avon, north of Ringwood, Hampshire, and Wythenshawe, Manchester.

WOLD. Anglo-Saxon, *wald*: a wood. Now applied to the Wolds of Lincolnshire and the East Riding of Yorkshire, which are chalk downlands, formerly well wooded.

WOOD. Anglo-Saxon, *wald*: a wood. The most usual English name for any area of ground covered by trees, whether of small or great extent. Example, Joydens Wood in Kent, and countless others.

WYTH. Occurs in the Lake District, as at Wythop, near Cockermouth, and said to signify a wood. May be connected with *withy*, q.v.

YEW. Welsh *yw*; *Taxus baccata* L. One of the rare instances of an old Welsh or British word being adopted into English. Place-names incorporating 'yew' are common in England, and some woods so named are certainly of great antiquity. An example is Great Yews, near Salisbury in Wiltshire.

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USE OF RANGE/STANDARD DEVIATION TABLES

By J. N. R. JEFFERS

(*Forestry Commission*)

SUMMARY.

Standard deviations of random samples drawn from normal populations may be estimated rapidly in the field from the ratio, range/standard deviation. A simple table of these ratios is given, together with a table showing the loss in precision involved in the method, and the increased sizes of samples needed to compensate for this loss.

CONSIDERABLE interest has been expressed in two notes published recently in *Nature* (1 and 5) on the rapid estimation of standard deviations by graphical methods. The chief need for rapid estimation of standard deviations in forestry is for field parties, who find it necessary to estimate the precision of data collected while still in the field, in order to determine whether or not a larger sample is necessary. For this purpose, even graphical methods tend to be a little tiresome, involving, as they do, the plotting of series of points and the measurement of distances on the graph.

A much simpler method, and one which will normally give reasonable estimates of population standard deviations, is described by Snedecor (2) and involves the use of the range/standard deviation ratio which is given in Table I below. This table is part of Table 5·5 of his *Statistical Methods* (2); it was tabulated by Tippett (4) and is published by kind permission of the authors and publishers.

TABLE I. *Mean Values of the Ratio, Range/Standard Deviation* (r/σ), *in Random Samples of Size n drawn from the Normal Population*

n	*Mean value of* r/σ	*n*	*Mean value of* r/σ
2	1·13	20	3·73
3	1·69	30	4·09
4	2·06	50	4·50
5	2·33	75	4·81
6	2·53	100	5·02
7	2·70	150	5·3
8	2·85	200	5·5
9	2·97	300	5·8
10	3·08	500	6·1
15	3·47	700	6·3

The two measures of variation, range and standard deviation, are related, and the expected value of their ratio is known for a sample of given size. The table gives the ratio for various sample sizes from normal populations.

Thus, to quote an example, a random sample of 20 heights of dominant trees was measured, in which the maximum recorded was 39·5 feet and the minimum

28·0 feet, with an arithmetic mean of 33·4 feet. The standard deviation of the sampled population was estimated as the range divided by the tabulated ratio for $n = 20$, i.e. $\frac{+11{\cdot}5}{3{\cdot}73} = \pm 3{\cdot}08$. The calculated standard deviation was $\pm 2{\cdot}95$.

The calculated standard deviation(s) of a sample, and the standard deviation obtained by dividing the range by the appropriate ratio, both give valid and unbiased estimates of the standard deviation (σ) of the population from which the sample is drawn, but the calculated standard deviation is slightly more precise. The simplicity of the range/σ table is thus offset by a slight loss in precision. The loss in precision is illustrated by Table II, which is quoted from *Everyday Statistics* by G. W. Snedecor (3), and shows the sample size required if the range/σ ratio is used, as compared with sizes of samples of the same precision if s is the estimator.

TABLE II. *Sizes of Samples having Equal Precision if Calculated Standard Deviation(s) and Range/σ are used as Estimators of Population Standard Deviation (σ)*

Size if s is estimator	*Size if range/σ is estimator*	*Size if s is estimator*	*Size if range/σ is estimator*
7	8	20	29
8	9	22	32
9	10	24	37
10	12	26	41
12	15	28	45
14	18	30	50
16	21	40	75
18	25	50	102

Thus, a sample of 20 heights would have to be increased to a sample of 29 heights if it was required to estimate the population standard deviation with equal precision by using range/σ ratio instead of a calculated standard deviation. The added amount of field work involved in measuring 29 trees instead of 20 may be more than balanced by the saving in computational effort and by the fact that the estimate of standard deviation is available immediately.

Not only standard deviations of normal populations, but also range or sample numbers, may be estimated from the tabulated values, provided always that two factors are known. Thus, in a sample of 10 trees, the mean volume may be given as 57 cubic feet, with a standard deviation of $\pm 21{\cdot}1$ cubic feet. The reader, assuming normal distribution, may easily estimate the mean range of samples as being $21{\cdot}1 \times 3{\cdot}08$ cubic feet = 65 cubic feet. His estimate for the largest tree in an average sample would then be $57 + \frac{65}{2}$ cubic feet, i.e. approximately 100 cubic feet, and for the smallest tree $57 - \frac{65}{2}$ cubic feet, i.e. approximately 20 cubic feet.

The range/standard deviation table is not only useful for estimating standard deviations in the field. It is useful to check computations by this method, thus obtaining a rough check on the work.

LITERATURE REFERENCES.

(1) Smith, G. S.: *Nature*, clxiv (p. 718), 22 Oct. 1949.
(2) Snedecor, G. W.: *Statistical Methods* (Iowa State College Press, 1946).
(3) —— *Everyday Statistics* (William C. Brown, Iowa, 1950).
(4) Tippett, L. H. C.: *Biometrika*, xvii. 386, 1925.
(5) Woolf, B.: *Nature*, clxiv (p. 360), 27 Aug. 1949.

STEBBING PRIZE FUND

We are glad to be able to call the attention of members to the opening of a subscription list for the above purpose. Details will be found in the advertisement columns of this number.

SOCIETY'S AND OTHER NEWS

EXCURSION AND ANNUAL GENERAL MEETING, 1951

A SUCCESSFUL semi-jubilee meeting was held in Oxford from the 24th to the 28th September as arranged. Some further details will be given in the next number. It is hoped to hold the 1952 meeting in Dumfries and the 1953 meeting in North Wales. A meeting abroad in 1954 has been suggested.

NOMINATIONS FOR OFFICE BEARERS AND FOR FIVE COUNCILLORS

NOMINATIONS must be in the Secretary's hands by the 30th April. Details will be found on pages iii and iv above.

INCOME TAX COVENANT SCHEME

MEMBERS will have received particulars. A satisfactory response would relieve the Society of considerable financial anxiety and it is hoped that those members who have not yet come into the scheme will do so without delay.

FORESTRY, VOLUME VII, NUMBER I

THE Clarendon Press is anxious to buy in copies to make up a shortage. They would welcome offers of any spare copies that members may have for disposal.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE following papers on forest subjects were read at the meeting in Edinburgh in August 1951.

Sir Henry Beresford-Peirse, Bt.: 'British Forestry in the Last Century'.

Professor E. P. Stebbing: 'Forestry in the British Commonwealth in the Last Century'.

Dr. William Reid, Mr. B. C. Hollingsworth, and Mr. H. H. Wilson: 'The Use of Timber in Mining'.

Mr. C. W. Scott: 'The Properties and Uses of Conifer Thinnings'.

Mr. W. E. Hiley: 'The Grade of Thinning'.

Sir George Campbell, Bt.: 'Some Observations on Thinning in an Area of Rapid Growth'.

Mr. A. Watt: 'The Forests of Scotland, Past, Present and Future'.

Dr. F. Fraser Darling: 'Animals and Forestry'.

Mr. J. M. D. Mackenzie: 'The Encouragement of Birds in Plantations by Nest Boxes and other means'.

Dr. R. N. Chrystal: 'The Role of Insects in Forestry'.

Mr. A. B. Duncan: 'Birds and Forestry'.

Sir John Milne Home: 'The Introduction of Conifers and their Influence on Forestry'.

Dr. Malcolm Wilson: 'The Development of Forest Pathology in Recent Years'.

Mr. S. N. Banerjee: 'A Disease of Norway Spruce causing Fluting of the Bole'.

Dr. H. van Vloten: 'Evidence of Host-parasite Relations by Experiments with *Phomopsis pseudotsugae* Wilson'.

The papers by Messrs. Scott and Hiley are reproduced by permission in this number.

The British Association meeting in 1952 will be held in Belfast from the 3rd to 10th September.

REVIEWS

Census of Woodlands 1947–1949. Summary Report. Forestry Commission. Forest Record Number 3. London: His Majesty's Stationery Office, 1951. Price 6*d*.

Review by M. L. Anderson

THIS somewhat brief report is a summarized forerunner, it is understood, of a full report of the third and most comprehensive of the large-scale systematic surveys of British woodlands so far undertaken. It does not, therefore, deal in very great detail with methods of procedure nor does it give the data broken down into units smaller than those of the three countries which together go to form the island of Great Britain.

While the work has been carried out over a period of more than one year, from 1947 to the middle of 1949, the data are given as referring to the 30th September 1947. The earlier surveys were those of 1928 and of 1938–9, but, owing to the war intervening, figures for the latter were only partial and were not published.

The data are presented in a set of eleven tables, which refer only to woods of 5 acres or more in extent, but it is understood that a separate survey has been completed for smaller woods and belts, the results of which, when made available, will probably disclose a surprisingly high volume of timber of a kind, as happened when a similar survey was made in Ireland during the war.

For all purposes the data are given separately for private woodlands and State forests and in each table, except 11, separately for England, Scotland, and Wales, which thus enables one to draw quantitative comparisons between ownerships and countries. Table 1 classifies the woodland areas by type and broad composition into high-forest, coniferous, broad-leaved and mixed; coppice with and without standards; scrub, devastated and felled. Tables 2, 3, and 4 give the distribution of the woods by age-classes and broad composition and there is the usual difficulty about the uneven-aged category.

Tables 5, 6, and 7 give interesting information concerning the areas occupied by the major tree-species. This information would have been more informative and of greater value for future comparison if it had been given by broad age-classes. One would expect to find very great differences in composition between the first four age-classes up to 40 years of age, for example, and the last four classes.

Table 8 makes an attempt to classify the private woodlands only in respect of their suitability for economic management. The criteria for this cannot be very reliable and it seems certain that evaluation of the essential factors which have to be considered must have brought in a considerable element of subjectivity.

Table 9 presents an estimate of the over-bark volume of timber in the principal types of woodland, based on a, presumably, small sample; while Table 10 gives an estimate of the current annual volume increment, over-bark. Lastly, Table 11 is an attempt to indicate the distribution of this volume increment by types of woodland and age-classes for the whole country. One may conclude from this that of the total estimated annual increment of 97·3 millions of hoppus feet, no less than 54·2 millions are accruing to stands of 30 years of age or less, leaving only 43·1 millions for the older stands. The decision to present these data over-bark is a welcome improvement.

For those who like to dabble in figures the data presented provide opportunity to draw deductions in support or in contradiction of various theses. The text of the publication, after briefly outlining the methods employed, does this for each of the tables presented,

with explanatory notes, which in respect of the tables on volume and increment merit special attention.

National forest surveys are by no means easy to carry out, especially when the forest units consist of many small woods of varying size and composition in countries with varied relief. This report records definite improvements in method and presentation. Its greatest value will lie in the fact that it will constitute one record in a series of records which should give the broad history of forestry development in this country. Doubtless future surveys will employ improved procedures which will not only furnish more precise results but will do so at less cost. For example, it is clear that any system of standardized returns made under the dedication scheme and careful records kept in State forests could furnish extremely useful supplementary information, especially in respect of volume, increment, and proportion of defective timber in the total production. It is to be hoped, however, that silviculture and management will never be influenced by any feeling or insistence that they must conform to some rigid statistical schedule, unable, for example, to cope with the uneven-aged wood and the wood of mixed composition.

Then, again, it would have been extremely useful to have had information reflecting the range of size of private forest units in the several countries, an omission which could be remedied when, and if, a more comprehensive report is published.

Thirty-first Annual Report of the Forestry Commissioners for the Year ending September 30th, 1950. London: His Majesty's Stationery Office, 1951. Price 2*s.* 6*d.* net.

Review by W. E. Hiley

THE progress from year to year of the work of the Forestry Commission is followed by British foresters with intense interest and, with the lapse of time, their Annual Reports are building up the history of an outstanding forest achievement. These reports are well known and it is unnecessary to describe their layout; our interest is concentrated on the speed with which the programme laid down in the White Paper (1943) is being carried out.

The area planted, both in State and private woods, falls short of the programme and it will take more than the proposed 7 years to attain the rate of 150,000 acres a year at which it was to be stabilized. Nevertheless, progress has been rapid and, although the area planted on private estates is not precisely known, it appears that private owners have approached the target more nearly than the Commission. The figures for the first 4 years of the new programme are shown in the following table.

Areas planted and the White Paper Programme

(in thousands of acres)

	State							
	Afforestation		*Replanting*		*Private*		*Total*	
Year	*White Paper*	*Actual*	*White Paper*	*Actual*	*White Paper*	*Actual*	*White Paper*	*Actual*
1947	25	17·5	5	8·9	5	9	35	35·4
1948	30	23·9	13	12·5	10	11·1	53	47·5
1949	36	30·9	22	13·0	15	13·3	73	57·2
1950	42	37·3	30	16·4	20	15·0	92	68·7
Total	133	109·6	70	50·8	50	48·4	253	208·8

Foresters will agree with the Commissioners that, in view of the 1,310,000 acres of scrub, felled, and devastated land disclosed by the 1947 Census of Woodlands, replanting is not progressing as rapidly as it should and that the time has come when it is necessary to use their powers of compulsory acquisition to purchase woods which their owners are failing to restore. It may be hoped that when they have more old woodlands to replant the proportion of hardwoods planted will rise to more than 8 per cent., which was the figure in 1950. The area of plantable land acquired during the year was somewhat higher at 61,000 acres, but this is insufficient to support a rapidly expanding programme.

The area thinned, at 31,996 acres, is a little above that for 1949 but is surprisingly low, since the Commission's plantations of 15 years and over amounted to nearly 300,000 acres. The area of private woods for which thinning grants were paid was 16,724 acres and no doubt an additional area was thinned without grants. Scotsmen will be proud to learn that about two-thirds of this area was in Scotland and, though their foresters must be congratulated on this achievement, it may in part be due to the active participation of the timber trade in buying standing thinnings and preparing pit-props and other produce. The development of a similarly co-ordinated service in England and Wales would greatly assist in the proper maintenance of plantations on southern estates.

Of the nursery area of 2,270 acres, 342 acres were of the new heathland type. About 127 million plants were sent out from the nurseries, of which 18 million were sold to the trade, so the output was about 56,000 per acre; about a third of the nursery area, however, was under fallow or green crops and only 755 acres were carrying transplant lines. The most interesting feature in the table of imported seed was a purchase of some 13,000 lb. of red oak from Holland.

The total expenditure of the Commission during the year was rather over £7·2 millions of which nearly £1·7 million was covered by receipts. 'Forestry Operations' absorbed £6·6 millions, including £2·1 millions for 'cultural operations', £0·95 million for supervision and overheads, and £0·7 million for the preparation and sale of produce; and large sums were spent on roads, buildings, stores, &c. These figures are analysed to some extent in the tables at the end of the report, and enough information is provided to allow some rough guesses to be made of the unit costs of various activities based on the known total cost and the amount of work done. For this purpose all relevant overhead costs and incidental expenses have to be spread on a percentage basis and, as the item 'miscellaneous' amounts to no less than £616,133, the method rides roughshod over the niceties of costing. And in many instances results are vitiated by the difficulty of making suitable allowances for an expanding programme. Nevertheless, the results obtained by this crude method are for many purposes more valuable than the detailed costs of particular operations since they include the failures with the successes and are representative of average costs. They thus provide a safer foundation for estimating the cost of cultivating forests and producing round timber.

When worked out in this way it appears that all the main costs were lower in 1950 than in 1949. The cost of nursery plants sent out from the nurseries averaged about £6 per 1,000 in place of £7; the cost of preparation of ground, plants, planting, rabbit control, and beating up was £37 per acre in place of £43; and the total cost of establishment and bringing an acre of plantation through to about 20 years *at the current rates of expenditure* was about £76 instead of £84. On the credit side the net surplus on the sale of thinnings and final crops was about £180,000 in place of £60,000. One thousand two hundred and twenty-one acres of forest were clear-felled, but many of these stands were no doubt of very poor quality, and most of the surplus was probably earned on the 32,000 acres which were thinned.

In working out these costs no account has been taken of expenditure on roads and buildings which can more appropriately be added to the cost of land. Expenditure on the 'acquisition of land, &c.' was very small at £268,000, but, after adding their appropriate share of overhead charges, the cost of roads and buildings was of the order of £2 millions. It is well known that the value of a farm lies less in the intrinsic wealth of the soil than in the cost of man-made improvements; these figures show that the same generalization applies to forest land.

To those who are unacquainted with the results of impartial forest costings it may appear that the work of the Forestry Commission is unduly expensive. My experience, however, suggests that even on private estates the costs of forestry operations, when all pertinent charges have been included, may be shown to be of a similar character. When the Universities of Oxford and Aberdeen have collected and analysed the costs of forestry on representative estates it will be possible to compare them with those of the Commission. We shall then know whether the savings which are achieved through planting large areas, many of which are on bare land, are sufficient to counterbalance the heavy overhead charges which are inevitably incurred by a vast and complicated organization such as a government department.

The achievement which is recorded in the Annual Reports of the Forestry Commission is the result of the enthusiastic co-operation of foresters of all ranks. Statistical tables tend to conceal the human beings who are doing the work, but we who belong to the same profession may take pride in the monumental task which our fellow foresters have undertaken.

Values and Integrals of the Orthogonal Polynomials up to n = 26. By D. B. DeLury. University of Toronto Press (London: Geoffrey Cumberlege), 1950. Pp. 33. 9*s.* 6*d.*

Review by D. J. Finney

THE way in which orthogonal polynomials can expedite the fitting of curves by the method of least squares has long been familiar. In their *Statistical Tables* Fisher and Yates have provided a table to assist the use of polynomials up to degree 5 for 52 or fewer equally spaced values. Dr. DeLury follows the same scheme of tabulation, but gives the complete set of polynomials for all numbers of equally spaced values up to 26. The rapid fitting of an equation of the twenty-fifth degree to a set of 26 observations thus becomes possible.

Dr. DeLury states that he has prepared his table primarily because he believes that it may be useful in assessing the precision of systematic sampling by line transects and by two-dimensional grids. He gives an example of its application to estimation of the total number of trees in an area, from counts on a small number of equally spaced plots, and clearly has in mind applications to forest sampling. Interesting though this idea is, my own work on volume estimation of standing timber (reported in recent papers in this journal) makes me doubtful whether trustworthy assessments of standard errors of estimates will generally be given by it. The primary source of interrelationship between yields on separate plots of a forest is likely to be an irregular correlation between adjacent areas rather than a regular trend. If the whole forest consisted of, say, 500 plots, a polynomial of very high degree might be needed in order to represent the trend adequately; a polynomial equation fitted to records of a 5 per cent. systematic sample need not approximate at all closely to this. An extreme instance is obvious on consideration of a periodic trend and a systematic sample with interval equal to the period: a polynomial of degree zero (i.e. a horizontal line) might fit the *sample* values almost perfectly, but would bear no relation to the real trend, and the

small standard error assessed from the sample would give an entirely false impression of the precision of the estimate.

For the reason that I have indicated, I personally shall be surprised if the method proposed proves valuable in forest sampling. The decision between Dr. DeLury's opinion and mine, however, does not rest with statistical theory but with experience of how forests do in fact vary. By analysis of data from a complete enumeration, using methods that I have described previously, the precision of systematic samples from that area can be investigated. If application of the polynomial method to the data of a single systematic sample is found to give practically the same standard error, then for that area the polynomial method is satisfactory; if, as I suspect will often happen, it gives a substantially lower standard error (occasionally, perhaps, substantially higher), then it will be misleading. My criticism here is not intended to prejudge a complicated matter, and aims only at ensuring that judgement be suspended until arithmetical analysis of several complete enumerations has been performed and discussed. Forestry workers and statisticians will have cause to be grateful to Dr. DeLury if this experience shows the polynomial analysis of systematic samples to be profitable, but they must beware of assuming that, because the method is easy and gives *an* answer, therefore it is valid and gives the *correct* answer. In any event, this new table is sure to find many other uses in the statistical analysis of scientific data.

Colony and Protectorate of Kenya. An Economic Survey of Forestry in Kenya and Recommendations Regarding a Forest Commission. Kenya: The English Press Ltd., 1950. 2*s*.

Review by J. J. MacGregor

MANY countries have found it desirable since the Second World War to take stock of their forest policy and to remodel it in the new and prospective circumstances. In Kenya a committee consisting of W. E. Hiley, P. J. Gill, and A. K. Constantine have undertaken this particular task, at least on the economic aspects of policy. Although a fuller understanding of their report can only be adequately appreciated from a study of the events which led to its creation, to a large extent its special function can be gathered from the terms of reference:

'1. To consider the existing constitution of the Forest Department and the manner in which its finances are provided, and in the light of experience gained to investigate and report on the economic and financial aspects of the implementation of the Forest Development Programme recommended in the Report of the Development Committee of 1946, with special reference to the programme of softwood planting, and to advise whether the recommendations of that report should be modified in any way.

2. To consider and report on the proposal to establish a Forest Commission on the lines agreed by the Forest Advisory Committee and submitted to Executive Council and to recommend any consequential reorganization that may appear necessary.

3. To examine with a view to determining whether the administration of the Forest Estate as a self-financing unit is likely to be a sound financial proposition:

(*a*) under the existing Forest Development Programme, or

(*b*) under an accelerated programme such as recommended in the Marquand Report, and what period, if any, is likely to elapse before the projects can be expected to be self-supporting, and to advise how any shortfall in revenue compared with expenditure should be financed during that period.

4. To make recommendations on rates and method of collection of royalties and on other methods of collecting revenue from Forest products.

5. To report on any major foreseeable difficulties which may prejudice or endanger the proposed projects.'

After giving its summary, conclusions, and recommendations, the report relates the history of the more significant events shaping the need for a new stocktaking. These events included the Development Committee's Report of 1946, the Marquand Report of 1948, and the idea of the Forestry Commission suggested by Mr. J. C. Rammell, then Conservator of Forests in Kenya. The idea of a Forest Commission is supported without qualification on commercial grounds and as a means of ensuring the essential finance for most of the forestry policy.

The section which covers the structure of the existing forests emphasizes the need for a forest survey and commends an aerial survey, supported by ground measurement of timber stock on sample areas, as the quickest and cheapest method. A broad assessment of the existing forests and the more important economic species are mentioned. Until more knowledge is available the planting of hardwoods should be limited to 1,000 acres per year, but the committee is emphatic in its support for the planting of exotic conifers which are shown to be a very attractive investment in Kenya. Any large-scale development of protection forests should have specific government grants and not be a charge on the Forestry Commission.

The committee shows caution when it comes to consider the demand and supply of timber. Its view, however, is that the native consumption may increase to several times its present low level. Fears of a timber famine, which were reckoned as a possibility within 50 years if reliance had been placed on the indigenous forests, had been avoided by the policy of replanting. The programme previously set by the Development Committee would eventually form 210,500 acres, and yield about 25–30 million cubic feet of sawn timber annually. However, in the absence of planting limits, the ultimate area might be much greater—a situation which could only be justified by a large volume of exports. Although an immediate increase in exports was desirable to absorb the expected increase in fellings, the committee were more concerned with the export outlets in 15 to 30 years when the new plantations would be productive. Although the existing programmes output was likely to be much larger than for Kenya's domestic needs, it was small in relation to world or even British trade. A quotation from the Marquand Report stressed the uncertainty of forecasting the world softwood supplies in 30 years but noted the increasing difficulties of obtaining supplies from the former exporting countries. The committee are, however, optimistic about Kenya's ability to compete in the future: not only has she a very great comparative advantage in the growing of trees, but the concentration and uniform quality of the plantations should help to ensure efficient saw-milling. Using the usual formula, and making generous allowances for costs, rates of return as an investment of nearly 10 per cent. are calculated on rotations of from 25 to 30 years.

The section on price of standing timber shows the theoretical relationship between standing and sawn timber and describes the method of levying royalties in Kenya. The committee strongly argued the case for doubling the level of royalties, and regarded anything less as being unrealistic and insufficient to replant the felled areas and cover the other commitments of the Forest Department. They would even then be less than the free market price for standing timber. It was estimated that an increase of 12–14 per cent. in the control price of sawn timber would recoup saw-millers for a doubling of the royalty. The committee also considered that sales by tender would be an appropriate method for

plantations but not for the indigenous forests. They gave support, however, to the method of charging a percentage of the f.o.r. prices of sawn timber which would render the equivalent of a doubling of the royalty. Certain temporary difficulties would be associated with the change-over.

In examining the factors likely to influence the future expenditure of the Forest Commission, the committee suggested that expenditure should be at the rate of £225,000 in 1951, rising by annual steps of £5,000. They were convinced that forest development in the colony should be self-supporting, and proposed four expedients for increasing revenue: (1) the cut of standing timber in the indigenous forests should be increased by 20 per cent. during the next 15 years; (2) standing timber prices should be doubled; (3) the Forest Commission should be reimbursed by the Government for the cost to it of managing Native Forest Reserves; and (4) if an additional source of finance were needed some of the new plantations could be felled prematurely. Subject to important reservations the committee felt that the cost of the existing programme could be met without resort to the last expedient. Indeed, if the expectations were realized, an annual surplus would be available to build up the Forest Fund. The function of this fund, apart from assisting to relieve unemployment and reduce the effects of depression, is to ensure a continuity of the programmes even if a trade depression should set in. In spite of the favourable things claimed earlier for Kenya's ability to compete, it is recommended that the fund should equal three times the Commission's annual expenditure. In the period before the fund has been built up to this level the Government should guarantee bank overdraft facilities up to £450,000. With existing assets, this would bring the amount up to the £750,000 aimed at.

The committee give explanations, in some detail, of their views about the constitution, the powers which will be reserved to the member representing the Forest Commission in the legislature, and the type of man who should be a Commissioner, and the staffing arrangements. The main responsibility of the Commission would be to operate and manage the Crown Forests including the protection forests. For the Native Forests the Forest Commission would act as a Government agent. Although the committee urged that the Forest Commission should present annual accounts and a report to the member, for submission to the Legislative Council, it did not commit itself about the form which the accounts should take. It, however, explained at some length the difficulties which would be involved. The accounts could only be worked out 'as a result of practical experiment' and the recommendation leaves it to the fully qualified accountant to work out the way. One of the members of the committee, Mr. P. J. Gill, does make suggestions about a system of accounting and this appears as an appendix in the report. Another appendix gives the proposed skeleton constitution for a Forest Commission as prepared by Mr. J. C. Rammell when Conservator of Forests. The last appendix is prepared by Mr. A. K. Constantine, one of the members of the committee, and he examines the expected earnings of the Forest Commission. This summarizes for a complete rotation of exotic softwood plantations the various estimates, totals, and recommendations of the committee. It includes reservations about the possible effect of depressions.

It is clear that the committee were faced with many important decisions, some of which, if put into practice, will have far-reaching influences on policy—not only in Kenya but probably in other colonies as well. On the one hand, the committee's task was simplified since the terms of reference were precise and full. Part of their undertaking was to evaluate proposals and programmes and for this purpose adequate evidence was available to develop substantial arguments in favour of modifications, or of something more revolutionary. On the other hand, the committee had to face the real difficulty of estimating the trend of demand for timber and many 'ifs' have to be swallowed before all the recommendations are likely

to meet with full acceptance. The fundamental recommendation is the setting up of the Forest Commission and the subsidiary recommendations give it additional support. Many will approve of the idea in that it will give the Forestry Department an opportunity to plan its own work in relative financial security. The fact remains, however, that doubts will be raised, for instance, about the ability to use civil servants, with their own special administrative methods and status, in a commercial undertaking, about the relative neglect of the protection areas, and about the ability to cater for domestic needs. The Crown and Native Forests do not represent more than a very small fraction of the total land area of the colony, and even within this area the Forest Commission would apparently be largely occupied in exploiting and maintaining the plantation areas. Although the likelihood of neglect of the 'non-productive' functions is capable of exaggeration the idea that the Native Forests should carry a larger proportion of the overheads raises a question about the precise function expected of forests in Kenya and other colonies. Many of the colonial forest policies stress the essential need to cater, in the first place, for the needs of the local population. The selection of the more directly remunerative activities may well be reckoned as a sound commercial principle, but a forest policy must also ensure that the following of this principle is reflected back in wider social gains. A little more consideration of this aspect would hardly have been outside the terms of reference and would have given a better balance to the Survey. Presumably while the Forest Fund is being built up there will be no net contribution to the colonial revenue, but it is not at all clear what form of investment will be taken by the fund. In these circumstances, one questions whether this procedure is the most appropriate. Experience in other lands has certainly pointed to the need in forestry policy for regularity of finance and freedom from budgetary control. A fund is one way of achieving this aim. If, however, the Forestry Commission is invoked to apply business methods, the granting of overdraft facilities—recommended by the committee for the early stages—would appear at first sight to be more flexible and less cumbersome. Moreover, it would carry a more direct inducement to maintain the careful financial procedure implied in the proposed administration. It might also, from the national viewpoint, represent a better use of the national income and capital. There is an air of inconsistency about associating a large-scale fund with the contention that there is outstanding efficiency in the growth of trees. It may be compatible with the main objectives of the Forest Commission to raise the standing price of timber; but if, as the committee points out, the demand for it is very elastic, what will be the effect of doubling the royalty on the trend of domestic consumption? Some forestry departments, as in India, which have had considerable experience in dealing with sales might feel that the committee have made light of their particular business abilities. Any action which is taken on this report is likely to be watched with considerable interest in other colonies. Is Kenya willing to take the risk, or the kudos, in pioneering new methods of colonial forest administration?

Report on Forest Research for the Year ending March 1950. Forestry Commission. London: His Majesty's Stationery Office, 1951. Price 3*s.* 6*d.* net.

Review by W. E. Hiley

THE Reports on Forest Research, of which this is the second to be issued, provide exciting reading for British foresters. This number contains some thirty signed articles by men and women who are studying those problems of silviculture and pathology

which are considered to be most important at the present time. It enables us to hear from them the more important experimental results which they have obtained, and to venture in thought along the paths which informed speculation seems to be opening up. It would be unfair to say that the writers have talked to us with irresponsible candour; but they have spared us the drudgery of detailed description of methods and analysis of results and have given us a quick insight into what they are up to. In reviewing such a report it is impossible even to refer to all its interesting contents; foresters must get it and read it for themselves. All we can do is to pick out incidental bits of information.

In nursery work the most exciting lines are soil sterilization with steam or formalin and the use of chemical manures, which appear to be as effective as composts in stimulating growth. Grading of Sitka spruce seedlings proved to be less important than was expected and the survival of transplants depends more on the proportion between height and stem diameter than on actual size; with Douglas fir and European larch grading is more important, particularly when the trees are being lifted from the transplant lines.

On heathlands the only species which succeed without nurses are pines and Japanese and hybrid larches; when mixed with broom, however, a wide range of conifers, and some hardwoods, can be established. The influence of hardwoods on podsolized soils is being studied by Mr. Dimbleby whose early results are encouraging. 'It appears that within one generation from the colonisation of moorland' by hardwoods 'there is an increase of pH of one unit, the leached layer becomes enriched in incorporated humus, and disintegration of the pan allows root penetration deeper into the soil.'

It has been thought that oak needs to be planted very closely, but Mr. Wood assures us that, on suitable sites and with adequate tending, a spacing of 4 by 4 feet gives satisfactory crops. Even a wider spacing may be allowable. On very weedy sites transplants have given better results than seedlings. Spacing trials with conifers, which were started in 1935–6, have been assessed and, though they are as yet inconclusive, it appears 'that on good sites wider planting distances than those current at present could be adopted'. A long-term experiment, which has been started at Alton Forest to test methods of rehabilitating degraded broad-leaved woodlands with as little replanting as possible, may give valuable results in the course of time.

The study of forest genetics is a new undertaking for the Commission. Mr. Matthews, who is in charge of it, is adopting three principal methods of improving the inherent quality of the trees we plant. The first is by 'mass selection'; the best stands which were found in the 1947 Census of Woodlands will be used as sources of seed, the bad trees having been removed. The second is 'mother tree selection', using individual well-formed trees, the progeny from which will be tested against a standard race with a view to the formation of 'seed plantations'. The third is by 'selection of both parents' which involves controlled pollination or vegetative reproduction. 'Seed orchards' will be formed of outstanding types and will be used for seed supply and for hybridization. These methods are being applied to many species but, at first, special attention is paid to Corsican pine and beech.

Provenance experiments, which were started many years ago, are reported on by Mr. Wood and Mr. Pinchin.

Under the title 'Studies of Growth and Yield' Mr. Hummel reviews the results of remeasurement, during the year, of 95 of the 427 permanent sample plots. The five oldest sample plots measured, Corsican and Scots pine over 80 years and Douglas fir and Sitka spruce over 70 years, all have a current annual increment of more than 100 h. ft. o.b. per acre, an observation which will encourage long rotations. Plots of widely spaced oak show that in Quality Class II sites, starting from a small number of trees, a crop of 26 trees per acre with a volume of 1,460 h. ft. o.b. and a b.h.q. girth of 20 inches can be produced in 100 years.

Mr. Brown's ecological study of beech woods indicates that good beech stands may be grown on acid soils. He emphasizes the harmful effect of wind on the floor of beech forests and the importance of intelligent thinning. Mr. Peace's pathological investigations cover a long list of tree diseases. *Phaeocryptopus gaumanii*, which causes needle cast, is responsible for the sickly appearance of much Douglas fir in the west, but there is somewhat better news about Dutch elm disease. Mr. Hanson has specialized on saw-flies which attack larch.

Mr. Shaw, the new Machinery Research Officer, is working on tractors, cableways, and many other mechanical devices and will, we hope, give us useful ideas in the future.

Of the reports submitted by researchers who are not directly engaged by the Commission the longest and most informative is that by Dr. E. M. Crowther on nutrition problems in nurseries. His results, which have already been briefly mentioned, are worthy of careful study. The notes on the fauna, fungi, and chemistry of humus in forest soils refer to long-term investigations which will mature later.

Lastly we must refer to Mr. James Macdonald's Introduction and Mr. M. V. Laurie's Summary of the Year's Work. It is to these two, in particular, that we are indebted for the publication of these preliminary results of research. British foresters will thank them for devoting so much time and energy to producing a report which contains information for which we might otherwise have had to wait many years, and, like television, gives us a sense of participating in current events.

Guide to the National Pinetum and Forest Plots at Bedgebury. Forestry Commission. London: His Majesty's Stationery Office, 1951. 2s. 6*d*.

Review by F. T. Brooks

THE publication of this attractive guide will be warmly welcomed by foresters and botanists, and indeed by all who love trees. Sir Geoffrey Evans, chairman of the joint committee of the Royal Botanic Gardens, Kew, and the Forestry Commission responsible for the National Pinetum, contributes an interesting Foreword about its establishment in 1924 and subsequent development. One of the reasons which led to the foundation of a new Pinetum was the concern of Sir John Stirling Maxwell and the late Sir Arthur Hill about the damage to the conifers at Kew owing to the polluted metropolitan atmosphere. The Forestry Commission strongly supported the proposal to establish a new Pinetum on their land, and eventually a part of Bedgebury Forest, in the High Weald of Kent, near the Sussex border, was chosen as the site. Planting began in 1925 under the zealous direction of Mr. W. Dallimore of Kew, who remained honorary curator until retirement in 1945. In addition, in 1929 Forest Plots of conifers and selected hardwoods began to be established by the Forestry Commission, so that there is now much of silvicultural interest also at Bedgebury. During the war the Pinetum had to be put on a maintenance basis, and in 1942 there was a serious fire in the forest which spread to the Forest Plots and destroyed some of them. In 1948 a superintendent of the Pinetum and Forest Plots was appointed.

The guide opens with a description of the topography, soils, and climate of the locality, and an historical account of Bedgebury Forest and of its development since acquisition by the Commission. This is followed by Mr. Dallimore's comprehensive description of the Pinetum as it existed in 1949. The Pinetum covers 64 acres and includes some 250 species and varieties of conifers as well as some hardwoods. In general the species are grouped according to genera, but occasionally this plan has been modified. In the accounts of the species there are valuable notes on their behaviour during the severe winter of 1939–40 and on their liability to damage by late spring frosts.

Many exotic species have grown well, others moderately, while some have virtually succumbed. By soil treatment some species that did not thrive at first have been satisfactorily established. The growth of species of the following genera is described in detail: *Larix*, *Cedrus*, *Juniperus*, *Sequoia*, *Picea*, *Abies*, *Pseudotsuga*, *Thuja*, *Cupressus*, *Chamaecyparis*, and *Pinus*. Among the spruces *Picea omorika* has done particularly well. Silver firs from Western North America have grown satisfactorily, unlike species from other regions. Among the cypresses *Cupressocyparis leylandii*, a hybrid between *Cupressus macrocarpa* and *Chamaecyparis nootkatensis*, has been most successful and has proved to be perfectly hardy; as it can be propagated from cuttings it shows promise as a forest tree. Among the pines all the forms of Corsican, Austrian, and Scots pines have flourished, and there are some vigorous trees of *Pinus pinaster*, although they have been difficult to make wind-firm. *P. resinosa*, *P. contorta* var. *latifolia*, and a few other pines have also grown well. On the other hand, five-needled pines have generally succumbed to blister rust. Among other conifers *Cunninghamia lanceolata*, *Cryptomeria japonica*, *Libocedrus decurrens*, *Sciadopitys verticillata*, and Western North American hemlocks have also proved satisfactory. Many broad-leaved trees have also been planted. Species of *Quercus*, *Betula*, *Robinia*, *Sorbus*, *Nothofagus* (from Chile), and *Tilia* are thriving, but species of *Acer* and *Aesculus* have mostly failed, perhaps owing to lack of lime in the soil. Natural regeneration of some of the conifers and hardwoods is already occurring.

Mr. R. F. Wood, silviculturist of the Forestry Commission, describes in detail the Forest Plots which extend over about 40 acres. There are 110 plots, of which 97 were occupied in 1949, the first having been planted in 1929. Most plots are $\frac{1}{4}$ acre, nearly square with rides between them. Twenty-nine plots, mostly of provenance collections, were destroyed by fire in 1942, but 16 have since been replanted with other species. Sixty-seven plots are considered to be fully established, some having been thinned at least once, but others are too young for accurate assessment. Height growth is measured regularly, and after thinning has begun information is obtained about volume production and increment. A few species have failed badly, among them *Abies delavayi*, *Pinus lambertiana*, *Eucalyptus gunnii*, *Juglans regia*, *Platanus orientalis*, and species of *Ulmus*, due either to frost injury or competition from chestnut coppice and seedling birch. Among the notable successes are the plots of *Abies grandis*, *Betula lenta*, *Chamaecyparis lawsoniana*, *Larix decidua* (the three plots from Scottish seed being superior to the two from continental sources), *L. leptolepis*, Hybrid Larch, *Nothofagus obliqua*, *Picea omorika*, *Pinus sylvestris* (of diverse provenance), *P. resinosa*, *Pseudotsuga taxifolia* (coastal form), *Quercus borealis* (*rubra*), and *Tsuga heterophylla*. Comprehensive growth records of most of the species are provided. As time proceeds many other valuable data will accrue from these plots.

The guide contains complete lists of the conifers in the Pinetum and of all species in the Forest Plots, the nomenclature having been checked by Dr. R. Melville of Kew. Plans of the Pinetum and the Forest Plots are provided, and there is a sketch map of the approaches to Bedgebury Forest. There are some excellent photographs, taken by Mr. M. Nimmo, assistant silviculturist of the Commission. Commendation is due to Mr. J. Macdonald and his colleagues for their efficient editorial oversight, and congratulations should be offered to all concerned on this notable addition to the publications of the Forestry Commission.

This guide should have the widest possible circulation, for Bedgebury should become a Mecca to foresters, arboriculturists, botanists, and all lovers of the countryside. As regards botanists, they can hardly find elsewhere in the country such a diverse and interesting collection of conifer genera.

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